System Manual
PLCcore-5484

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1 Introduction

Thank you that you have decided for the SYS TEC PLCcore-5454. This product provides to you an innovative and high-capacity PLC-kernel which – due to its numerous interfaces – is well-suitable as communication and control processor for embedded applications.

Please take some time to read through this manual carefully. It contains important information about the commissioning, configuration and programming of the PLCcore-5484. It will assist you in getting familiar with the functional range and usage of the PLCcore-5484. This document is complemented by other manuals, e.g. for the *OpenPCS* IEC 61131 programming system and the CANopen-extension for IEC 61131-3. Table 3 in section 4.1 shows a listing of relevant manuals for the PLCcore-5484. Please also refer to those complementary documents.

For more information, optional products, updates et cetera, we recommend you to visit our website: http://www.systec-electronic.com. The content of this website is updated periodically and provides to you downloads of the latest software releases and manual versions.

Explanatory notes about EMC law for the PLCcore-5484

The PLCcore-5484 has been designed to be used as vendor part for the integration into devices (further industrial processing) or as Development Board for laboratory development (hard- and software development).

After the integration into a device or when changes/extensions are made to this product, the conformity to EMC-law again must be assessed and certified. Only thereafter products may be launched onto the market.

The CE-conformity is only valid for the application area described in this document and only under compliance with the following commissioning instructions! The PLCcore-5454 is ESD-sensitive and may only be unpacked, used and operated by trained personal at ESD-conform work stations.

The PLCcore-5484 is a module for the application in automation technology. It features IEC 61131-3 programmability, uses standard CAN-bus and Ethernet network interfaces and a standardized network protocol. Consequently, development times are low and hardware costs are reasonable. PLC-functionality is created on-board through a CANopen network layer. Hence, it is not necessary for the user to create firmware.

2 Product Description

The PLCcore-5484 as another innovative product extends the SYS TEC electronic GmbH product range within the field of control applications. In the form of an insert-ready core module, it provides to the user a complete and compact PLC. Due to CAN and Ethernet interfaces, the PLCcore-5484 is best suitable to perform decentralized control tasks.

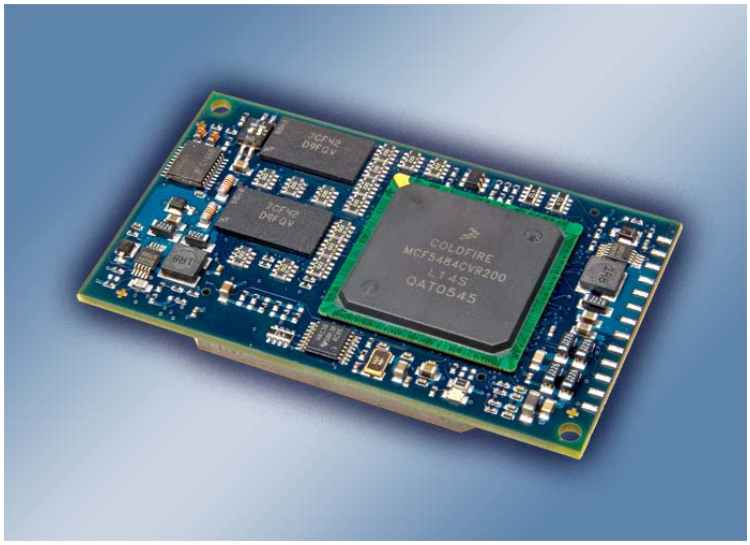


Figure 1: Top view of the PLCcore-5484

These are some significant features of the PLCcore-5484:

- High-capacity CPU-kernel (Freescale 32-Bit MCF5484 ColdFire, 200 MHz CPU Tact, 300 MIPS)
- 64 MByte SDRAM Memory, 16 MByte FLASH Memory
- 2x 10/100 Mbps Ethernet LAN Interface (1x with on–board PHY)
- 2x CAN 2.0B Interface
- 4x Asynchronous Serial Ports (UART)
- 24 digital inputs, 22 digital outputs
- 1 high-speed counter (Pulse/Dir or A/B)
- 1 PWM-/PTO output (Pulse/Dir)
- Externally usable SPI and I^2C
- On-board Peripherals: RTC, temperature sensor
- On-board Software: Linux, SPS-Firmware, CANopen-Master, HTTP and FTP Server
- Programmable in IEC 61131-3 and in C/C++
- Function block libraries for communication (CANopen, Ethernet and UART)
- Function block libraries for hardware components (RTC, Counter, PWM/PTO)
- Support of typical PLC control elements (e.g. Run/Stop switch, Run-LED, Error-LED)
- Linux-based (other user programs may run in parallel)
- Simple, HTML based configuration via WEB Browser
- Remote Login via Telnet
- Small dimension (70 x 40 mm)

There are different types of firmware available for the PLCcore-5484. They differ regarding the protocol used for the communication between Programming PC and PLCcore-5484:

Order number: 3390004:	PLCcore-5484/CANopen communication with Programming PC via CANopen Protocol (Interface CAN0)
Order number: 3390005:	PLCcore-5484/Ethernet communication with Programming PC via UDP Protocol (Interface ETH0)

Making PLC available as an insert-ready core module with small dimensions reduces effort and costs significantly for the development of user-specific controls. The PLCcore-5484 is also very well suitable as intelligent network node for decentralized processing of process signals (CANopen and UDP). Additionally, it can be used as basic component for special assemblies or as PLC in hard-to-access areas.

The on-board firmware of the PLCcore-5484 contains the entire PLC runtime environment including CANopen connection with CANopen master functionality. Thus, the module is able to perform control tasks such as linking in- and outputs or converting rule algorithms. Data and occurrences can be exchanged with other nodes (e.g. superior main controller, I/O-Slaves and so forth) via CANopen network, Ethernet (UDP protocol) and serial interfaces (UART). Moreover, the number of in- and outputs either is locally extendable or decentralized via CANopen devices. For this purpose, the CANopen-Chip is suitable. It has also been designed as insert-ready core module for the appliance in user-specific applications.

The PLCcore-5484 provides 24 digital inputs (DI0...DI23, 3.3V level), 22 digital outputs (DO0...DO21, 3.3V level), 1 high-speed counter input and 1 PWM/PTO output. Saving the PLC program in the on-board Flash-Disk of the module allows an automatic restart in case of power breakdown.

Programming the PLCcore-5484 takes place according to IEC 61131-3 by the *OpenPCS* programming system of the company infoteam Software GmbH (http://www.infoteam.de). This programming system has been extended and adjusted for the PLCcore-5484 by the company SYS TEC electronic GmbH. Hence, it is possible to program the PLCcore-5484 graphically in KOP/FUB, AS and CFC or textually in AWL or ST. Downloading the PLC program onto the module takes place via Ethernet or CANopen – depending on the firmware that is used. Addressing in- and outputs and creating a process image follows the SYS TEC scheme for compact control units. Like all other SYS TEC controls, the PLCcore-5484 supports backward documentation of the PLC program as well as debug functionality including watching and setting variables, single cycles, breakpoints and single steps.

The PLCcore-5484 is based on an embedded Linux operating system. This allows operating other user-specific programs while PLC firmware is running. If necessary, those other user-specific programs may interchange data with the PLC program via the process image. More information about this is provided in section 7.

The Embedded Linux applied to the PLCcore-5484 is licensed under GNU General Public License, version 2. Appendix B contains the license text. All sources of LinuxBSP are included in the software package **SO-1095** ("VMware-Image of the Linux development system"). If you require the LinuxBSP sources independently from the VMware-Image of the Linux development system, please contact our support:

support@systec-electronic.com

The PLC system and the PLC- and C/C++ programs developed by the user are **not** subject to GNU General Public License!

3 Development Kit PLCcore-5484

3.1 Overview

The Development Kit PLCcore-5484 is a high-capacity, complete package at a particularly favorable price. Based on a compact PLC, it enables the user to perform decentralized, network-compatible automation projects. Moreover, it facilitates the user to get to know the advantages of graphical and textual PLC programming according to IEC 61131-3 – compared to conventional programming languages.

Figure 2: Development Kit PLCcore-5484

The Development Kit PLCcore-5484 ensures quick and problem-free commissioning of the PLCcore-5484. Therefore, it combines all hard- and software components that are necessary to create own applications: the core module PLCcore-5484, the corresponding Development Board containing I/O periphery and numerous interfaces, the *OpenPCS* IEC 61131 programming system as well as further accessory. Thus, the Development Kit forms the ideal platform for developing user-specific applications based on the PLCcore-5484. It allows for a cost-efficient introduction into the world of decentralized automation technology. All components included in the Kit enable in- and output extensions of the PLCcore-5484 through CANopen-I/O-assemblies. Thus, the Development Kit may also be used for projects that require PLC with network connection.

The Development Kit PLCcore-5484 contains the following hardware components:

- PLCcore-5484
- Development Board for the PLCcore-5484
- 24V DC Power adapter
- Ethernet cable
- RS232 cable
- CD with programming software, examples, documentation and other tools

The Development Board included in the Kit facilitates quick commissioning of the PLCcore-5484 and simplifies the design of prototypes for user-specific applications based on this module. Among other equipment, the Development Board comprises different power supply possibilities, Ethernet interfaces, the connection of two independent CAN-buses, 5 push buttons and 5 LED as control elements for digital in- and outputs and it comprises a potentiometer for the analog input. Signals that are available from plug connectors of the PLCcore-5484 are linked to pin header connectors and enable easy connection of own peripheral circuitry. Hence, the Development Board forms an ideal experimentation and testing platform for the PLCcore-5484.

The *OpenPCS* IEC 61131 programming system included in the Kit serves as software development platform and as debug environment for the PLCcore-5484. Thus, the module can either be programmed graphically in KOP/FUB, AS and CFC or textually in AWL or ST. Downloading the PLC program onto the module takes place via Ethernet or CANopen – depending on the firmware that is used. High-capacity debug functionality such as watching and setting variables, single cycles, breakpoints and single steps simplify the development and commissioning of user software for this module.

3.2 Electric commissioning of the Development Kit PLCcore-5484

A 24V DC power adapter necessary for running the Development Kit PLCcore-5484 and Ethernet and RS232 cables are already included in the Kit delivery. For commissioning the Kit, it is essential to use at least the power supply connections (X700/X701), COM0 (X400 on top) and ETH0 (X500). Furthermore, connection CAN0 (X400 below) is recommended. Table 1 provides an overview over the connections of the Development Kit PLCcore-5484.

Table 1: Connections of the Development Kit PLCcore-5484

Connection	Labeling on the Demo Board	Remark
Power supply	X700 or X701	The 24V DC power adapter included in the delivery is intended for direct connection to X700.
ETH0 (Ethernet)	X500	This interface serves as communication interface with the Programming PC and is necessary for the program download (PLCcore-5484/Z5, order number 3390005).
ETH1 (Ethernet)	X501	Interface can be used freely for the user program.
COM0 (RS232)	X400 / on top	This interface is used for the configuration of the unit (e.g. setting the IP-address) and can be used freely for general operation of the user program.
COM1 (RS232)	X401 / on top	Interface can be used freely for the user program.
COM2 (RS232)	X402 / on top	Interface can be used freely for the user program.
COM3 (RS232)	X402 / below	Interface can be used freely for the user program.
CAN0 (CAN)	X400 / below	This interface serves as communication interface with the Programming PC and is necessary for the program download (PLCcore-5484/Z4, order number 3390004)
CAN1 (CAN)	X401 / below	Interface can be used freely for the user program.

Figure 3 shows the positioning of the most important connections of the Development Board for the PLCcore-5484. Instead of using the 24V DC power adapter included in the Kit, the power supply may optionally take place via X701 with an external source of 24V/1A.

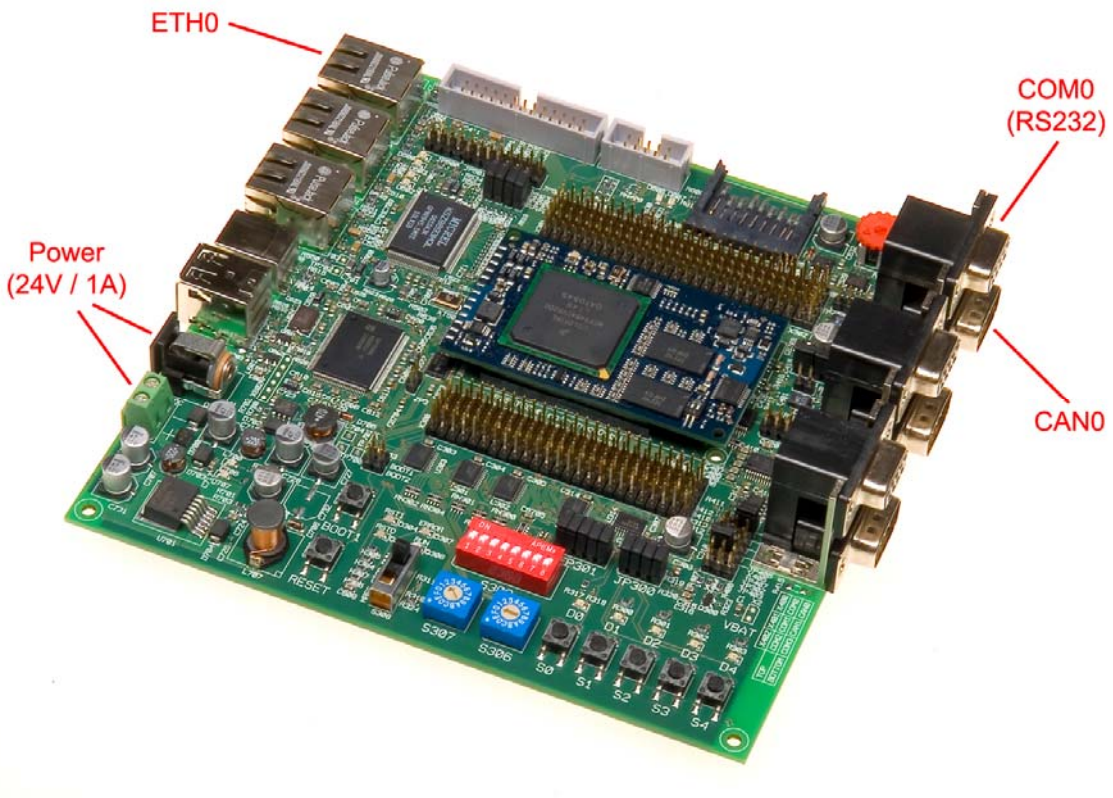


Figure 3: Positioning of most important connections on the Development Board for the PLCcore-5484

Advice:	**Upon commissioning, cables for Ethernet (ETH0, X500) and RS232 (COM0, X400 on top) must be connected prior to activating the power supply (X700 / X701).**

3.3 Control elements of the Development Kit PLCcore-5484

The Development Kit PLCcore-5484 allows for easy commissioning of the PLCcore-5484. It has available various control elements to configure the module and to simulate in- and outputs for the usage of the PLCcore-5484 as PLC kernel. In Table 2 control elements of the Development Board are listed and their meaning is described.

Table 2: Control elements of the Development Board for the PLCcore-5484

Control element	Name	Meaning
Pushbutton 0	S0	Digital Input DI0 (Process Image: %IX0.0)
Pushbutton 1	S1	Digital Input DI1 (Process Image: %IX0.1)
Pushbutton 2	S2	Digital Input DI2 (Process Image: %IX0.2)
Pushbutton 3	S3	Digital Input DI3 (Process Image: %IX0.3)
Pushbutton 4	S4	Digital Input DI4 (Process Image: %IX0.4)

LED 0	D0	Digital Output DO0	(Process Image: %QX0.0)
LED 1	D1	Digital Output DO1	(Process Image: %QX0.1)
LED 2	D2	Digital Output DO2	(Process Image: %QX0.2)
LED 3	D3	Digital Output DO3	(Process Image: %QX0.3)
LED 4	D4	Digital Output DO4	(Process Image: %QX0.4)
Poti (ADC)	R629	Analog Input AI0	(Process Image: %IW40.0)
Run/Stop Switch	S308	Run / Stop to operate the PLC program, Reset control (see section 4.7.1)	
Run-LED	D306	Display of activity state of the PLC (see section 4.7.2)	
Error-LED	D307	Display of error state of the PLC (see section 4.7.3)	
Hex-Encoding Switch	S306/S307	Configuration of node address CAN0 (see section 5.3.2)	
DIP Switch	S309	Configuration of bitrate and master mode CAN0 (see section 5.3.2)	

3.4 Optional accessory

3.4.1 I/O Extension Board for the PLCcore-5484

Due to limited space on the Development Board for the PLCcore-5484, only digital inputs DI0 to DI4 and digital outputs DO0 to DO4 are directly implemented via pushbuttons and LEDs. However, the I/O Extension Board for the PLCcore-5484 (order number 4004004) adapts all digital in- and outputs via pushbuttons and LEDs.

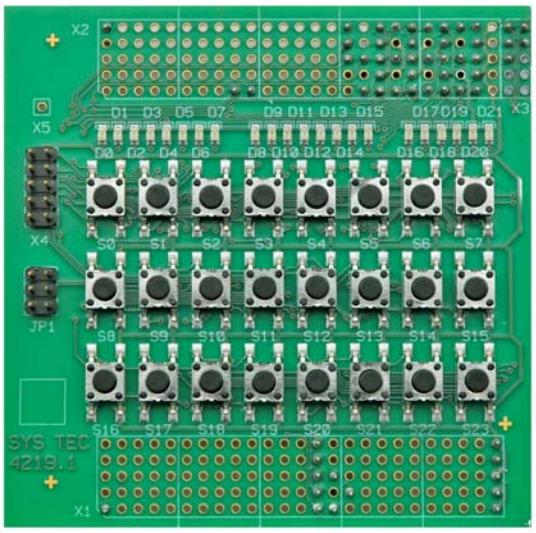


Figure 4: I/O Extension Board for the PLCcore-5484

3.4.2 USB-RS232 Adapter Cable

The SYS TEC USB-RS232 Adapter Cable (order number 3234000) provides a RS232 interface via an USB-Port of the PC. Together with a terminal program, it enables the configuration of the PLCcore-5484 from PCs, e.g. laptop computers which do not have RS232 interfaces themselves (see section 6.1).

Figure 5: SYS TEC USB-RS232 Adapter Cable

3.4.3 Driver Development Kit

The PLCcore-5484 Driver Development Kit (order number SO-1098) allows the user to independently adjust the I/O level to his own baseboard. Section 7.2. provides information about the Driver Development Kit.

4 PLC Functionality of the PLCcore-5484

4.1 Overview of relevant manuals for the PLCcore-5484

The PLCcore-5484 is based on SYS TEC ECUcore-5484 hardware and is extended by PLC-specific functionality (PLD software, firmware). There are different hardware manuals for all hardware components such as the ECUcore-5484 and the PLCcore-5484 (the hardware of both modules is identical), development boards and reference circuitry. Software-sided, the PLCcore-5484 is programmed with IEC 61131-3-conform *OpenPCS* programming environment. There are additional manuals for *OpenPCS* that describe the handling of programming tools and SYS TEC-specific extensions. Those are part of the software package. Table 3 lists up all relevant manuals for the PLCcore-5484.

Table 3: Overview of relevant manuals for the PLCcore-5484

Information about…	**In which manual?**
Basic information about the PLCcore-5484 (configuration, administration, process image, connection assignment, firmware update, reference designs et cetera)	In this manual
Development of user-specific C/C++ applications for the ECUcore-5484 / PLCcore-5484, VMware-Image of the Linux development system	System Manual ECUcore-5484 (Manual no.: L-1102)
Hardware description about the ECUcore-5484 / PLCcore-5484, reference designs et cetera	Hardware Manual ECUcore-5484 (Manual no.: L-1177)
Development Board for the ECUcore-5484 / PLCcore-5484, reference designs et cetera	Hardware Manual Development Board 5484 (Manual no.: L-1178)
Development Board for the ECUcore-Modules (Minimum version)	Hardware Manual Development Board ECUcores (Manual no.: L-1179)
Basics about the *OpenPCS* IEC 61131 programming system	Brief instructions for the programming system (Entry "*OpenPCS Documentation*" in the *OpenPCS* program group of the start menu) (Manual no.: L-1005)
Complete description of the *OpenPCS* IEC 61131 programming system, basics about the PLC programming according to IEC 61131-3	Online help about the *OpenPCS* programming system
Command overview and description of standard function blocks according to IEC 61131-3	Online help about the *OpenPCS* programming system
SYS TEC extension for IEC 61131-3: - String functions - UDP function blocks - SIO function blocks - FB for RTC, Counter, EEPROM, PWM/PTO	User Manual *"SYS TEC-extension for OpenPCS / IEC 61131-3"* (Manual no.: L-1054)

CANopen extension for IEC 61131-3 (Network variables, CANopen function blocks)	User Manual *"CANopen extension for IEC 61131-3"* (Manual no.: L-1008)
Textbook about PLC programming according to IEC 61131-3	IEC 61131-3: Programming Industrial Automation Systems John/Tiegelkamp Springer-Verlag ISBN: 3-540-67752-6 (a short version is available as PDF on the *OpenPCS* installation CD)

4.2 Pinout of the PLCcore-5484

Connections of the PLCcore-5484 are directed to the outside via two pin header connectors that are double-row and mounted on the bottom of the module. Appropriate female headers as correspondent to the PLCcore-5484 are available from company “Samtec“:

Samtec name: QSH Series
Samtec order number: QSH-060-01-F-D-A-K (deliverable in other sizes)

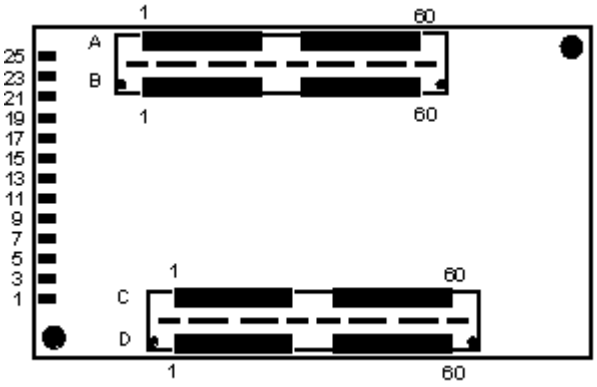


Figure 6: Pinout of the PLCcore-5484 - bottom view

Figure 6 exemplifies the positioning of pin header connectors on the PLCcore-5484. The complete connection assignment of this module is listed up in Table 4. Appendix A includes reference designs for using the PLCcore-5484 in customer-specific applications.

Table 4: Connections of the PLCcore-5484, completely, sorted by connection pin

Signal	Pin	Pin	Signal	Signal	Pin	Pin	Signal
PSTD0	A01	B01	/RSTI	2,5V_EPHY	C01	D01	GND
PSTD1	A02	B02	/MR	GND	C02	D02	Eth0_TX-
PSTD2	A03	B03	/RSTO	Eth0_RX+	C03	D03	Eth0_TX+
PSTD3	A04	B04	/BKPT	Eth0_RX-	C04	D04	GND
PSTD4	A05	B05	PSTCLK	GND	C05	D05	Link/Act
PSTD5	A06	B06	TCK	Speed	C06	D06	PFEC1H0
PSTD6	A07	B07	DSI	PFEC1L0	C07	D07	PFEC1H1
PSTD7	A08	B08	DSO	PFEC1L1	C08	D08	PFEC1H2

SCL	A09	B09	DSCLK
SDA	A10	B10	MTMOD0
PCI_AD0	A11	B11	PCI_AD1
PCI_AD2	A12	B12	PCI_AD3
PCI_AD4	A13	B13	PCI_AD5
PCI_AD6	A14	B14	PCI_AD7
PCI_AD8	A15	B15	PCI_AD9
PCI_AD10	A16	B16	PCI_AD11
PCI_AD12	A17	B17	PCI_AD13
PCI_AD14	A18	B18	PCI_AD15
PCI_AD16	A19	B19	PCI_AD17
PCI_AD18	A20	B20	PCI_AD19
PCI_AD20	A21	B21	PCI_AD21
PCI_AD22	A22	B22	PCI_AD23
PCI_AD24	A23	B23	PCI_AD25
PCI_AD26	A24	B24	PCI_AD27
PCI_AD28	A25	B25	PCI_AD29
PCI_AD30	A26	B26	PCI_AD31
PCI_TRDY	A27	B27	/PCI_IRDY
/PCI_CXBE0	A28	B28	PCI_PAR
/PCI_CXBE1	A29	B29	/PCI_PERR
/PCI_CXBE2	A30	B30	/PCI_SERR

PFEC1L2	C09	D09	PFEC1H3
PFEC1L3	C10	D10	PFEC1H4
PFEC1L4	C11	D11	PFEC1H5
PFEC1L5	C12	D12	PFEC1H6
PFEC1L6	C13	D13	PFEC1H7
PFEC1L7	C14	D14	E1MDIO
CAN_Rx0	C15	D15	E1MDC
CAN_Tx0	C16	D16	USB_D+
CAN_Rx1	C17	D17	USB_D-
CAN_Tx1	C18	D18	USB_VBUS
RxD0	C19	D19	RxD2
TxD0	C20	D20	TxD2
RxD1	C21	D21	RxD3
TxD1	C22	D22	TxD3
/PSC1_RTS	C23	D23	/PSC3_RTS
/PSC1_CTS	C24	D24	/PSC3_CTS
SPI_MTSR	C25	D25	SPI_CLK
SPI_MRST	C26	D26	/SPI_CS1
/SPI_CS2	C27	D27	/SPI_CS3
/SPI_CS4	C28	D28	/SPI_CS5
/SPI_CS6	C29	D29	/SPI_CS7
/FB_BWE0	C30	D30	/FB_BWE1

Signal	Pin	Pin	Signal
/PCI_CXBE3	A31	B31	/PCI_DEVSEL
PCI_IDSEL	A32	B32	/PCI_FRAME
/PCI_STOP	A33	B33	/PCI_RESET
/PCI_BG0	A34	B34	/PCI_BR0
/PCI_BG1	A35	B35	/PCI_BR1
/PCI_BG2	A36	B36	/PCI_BR2
/PCI_BG3	A37	B37	/PCI_BR3
/PCI_BG4	A38	B38	/PCI_BR4
FB_AD0	A39	B39	FB_AD1
FB_AD2	A40	B40	FB_AD3
FB_AD4	A41	B41	FB_AD5
FB_AD6	A42	B42	FB_AD7
FB_AD8	A43	B43	FB_AD9
FB_AD10	A44	B44	FB_AD11
FB_AD12	A45	B45	FB_AD13
FB_AD14	A46	B46	FB_AD15
FB_AD16	A47	B47	FB_AD17
FB_AD18	A48	B48	FB_AD19
FB_AD20	A49	B49	FB_AD21
FB_AD22	A50	B50	FB_AD23
FB_AD24	A51	B51	FB_AD25
FB_AD26	A52	B52	FB_AD27
FB_AD28	A53	B53	FB_AD29
FB_AD30	A54	B54	FB_AD31
FB_R/W	A55	B55	/FB_OE
VBAT	A56	B56	3,3V
3,3V	A57	B57	3,3V
3,3V	A58	B58	3,3V
3,3V	A59	B59	3,3V
3,3V	A60	B60	3,3V

Signal	Pin	Pin	Signal
/FB_BWE2	C31	D31	/FB_BWE3
/FB_CS2	C32	D32	/FB_CS3
/FB_CS4	C33	D33	/FB_CS5
FB_ALE	C34	D34	/DREQ0
/FB_TA	C35	D35	/BOOT
/DACK0	C36	D36	PFI
/IRQ5	C37	D37	/IRQ6
/IRQ7	C38	D38	TIN0
TOUT0	C39	D39	TIN1
TOUT1	C40	D40	TIN3
TOUT3	C41	D41	PLD_IO0
PLD_IO1	C42	D42	PLD_IO2
PLD_IO3	C43	D43	PLD_IO4
PLD_IO5	C44	D44	PLD_IO6
PLD_IO7	C45	D45	PLD_IO8
PLD_IO9	C46	D46	PLD_IO10
PLD_IO11	C47	D47	PLD_IO12
PLD_IO13	C48	D48	PLD_IO14
PLD_IO15	C49	D49	PLD_IO16
PLD_IO17	C50	D50	PLD_IO18
PLD_IO19	C51	D51	PLD_IO20
PLD_IO21	C52	D52	PLD_IO22
PLD_IO23	C53	D53	PLD_IO24
PLD_IO25	C54	D54	PLD_IO26
PLD_IO27	C55	D55	PLD_IO28
PLD_IO29	C56	D56	PLD_IO30
PLD_IO31	C57	D57	PLD_IO32
PLD_IO33	C58	D58	PLD_IO34
PLD_TMS	C59	D59	PLD_TDI
PLD_TCK	C60	D60	PLD_TDO

Table 5 is a subset of Table 4 and only includes all in- and outputs of the PLCcore-5484 sorted by their function.

Table 5: Connections of the PLCcore-5484, only I/O, sorted by function

Connector	Pin (CPU/PLD)	PLC Function 1	PLC Function 2 A=alternative, S=simultaneous
C56	PLD-P82 (IO29)	DI0 [Switch0]	A: DIP-Switch 6
B34	/PCI_BR0	DI1 [Switch1]	A: SD-card-protection
B35	/PCI_BR1	DI2 [Switch2]	
D39	TIN1	DI3 [Switch3]	
D40	TIN3	DI4 [Switch4]	
D37	/IRQ6	DI5 (onboard pullup)	
D23	PSC3RTS	DI6	
D38	TIN0	DI7	
D48	PLD-P63 (IO14)	DI8	S: CNTR0 (IN/A)
C49	PLD-P64 (IO15)	DI9	S: CNTR0 ('DIR/B)
D49	PLD-P65 (IO16)	DI10	
C50	PLD-P66 (IO17)	DI11	
D50	PLD-P67 (IO18)	DI12	
C51	PLD-P68 (IO19)	DI13	
D51	PLD-P69 (IO20)	DI14	
C52	PLD-P70 (IO21)	DI15	
D52	PLD-P71 (IO22)	DI16	A: DIP-Switch 1
C53	PLD-P72 (IO23)	DI17	A: DIP-Switch 2
D53	PLD-P73 (IO24)	DI18	A: DIP-Switch 3
C54	PLD-P76 (IO25)	DI19	A: DIP-Switch 4
D54	PLD-P77 (IO26)	DI20	A: DIP-Switch 5
C55	PLD-P78 (IO27)	DI21	
C23	PSC1RTS	DI22	
D55	PLD-P79 (IO28)	DI23	A: Config-Switch
D56	PLD-P83 (IO30)	DO0 [LED0]	
A35	/PCI_BG1	DO1 [LED1]	
A36	/PCI_BG2	DO2 [LED2]	
A37	/PCI_BG3	DO3 [LED3]	
A38	/PCI_BG4	DO4 [LED4]	
A34	/PCI_BG0	DO5	
C41	TOUT3	DO6	
C39	TOUT0	DO7	
D41	PLD-P46 (IO0)	DO8	
C42	PLD-P47 (IO1)	DO9	
D42	PLD-P49 (IO2)	DO10	A: PWM0 (OUT)
C43	PLD-P50 (IO3)	DO11	A: PWM0 ('DIR)
D43	PLD-P51 (IO4)	DO12	
C44	PLD-P52 (IO5)	DO13	
D44	PLD-P53 (IO6)	DO14	A: Hex-Switch 1-1
C45	PLD-P54 (IO7)	DO15	A: Hex-Switch 1-2
D45	PLD-P55 (IO8)	DO16	A: Hex-Switch 1-4
C46	PLD-P56 (IO9)	DO17	A: Hex-Switch 1-8
D46	PLD-P57 (IO10)	DO18	A: Hex-Switch 2-1
C47	PLD-P58 (IO11)	DO19	A: Hex-Switch 2-2
D47	PLD-P59 (IO12)	DO20	A: Hex-Switch 2-4
C48	PLD-P61 (IO13)	DO21	A: Hex-Switch 2-8

B37	/PCI_BR3	/Error-LED
B36	/PCI_BR2	/Run-LED
D57	PLD_IO32	R/S/M-Switch (see below)
C58	PLD_IO33	R/S/M-Switch (see below)
D58	PLD_IO34	R/S/M-Switch (see below)
D35	/BOOT	equivalent to on-board DIP2, see chapter 5.1

Table 6 defines the coding of the Run/Stop switch. Functionality of the Run/Stop switch for PLC firmware is explained in section 4.7.1. If no Run/Stop switch is intended for the usage of the PLCcore-5484 on an application-specific baseboard, the coding for *"Run"* must be hard-wired at the module connections (also see reference design in Appendix A).

Table 6: Coding of the Run/Stop switch

Modus	Pin D57 (PLD_IO32)	Pin C58 (PLD_IO33)	Pin D58 (PLD_IO34)
Run	1	0	1
Stop	1	1	0
MRes	0	0	0

4.3 File system of the PLCcore-5484

Pre-installed embedded Linux on the PLCcore-5484 provides part of the system memory in form of a file system. Being usual for embedded systems, most of this file system is “read/only” which means that changes to this part can only be made by creating a new Linux image for the PLCcore-5484. The advantage hereby is the resistance of a read/only file system against damages in case of power breakdowns. Those occur relatively often in embedded systems because embedded systems are usually simply turned off without previous shutdown.

Table 7 lists up writable paths of the file system during runtime. Path **"/home"** comprises a flash disk that provides part of the on-board flash memory of the PLCcore-5484 as file system. This path is used to store all files modifiable and updatable by the user, e.g. configuration files, PLC firmware and PLC program files that have been loaded onto the module. Directory **"/tmp"** is appropriately sized to function as temporary buffer for FTP downloads of firmware archives for PLC software updates (see section 6.7.1).

Table 7: File system configuration of the PLCcore-5484

Path	Size	Description
/home	5632 kByte	Flash disk to permanently store files modifiable and updatable by the user (e.g. configuration files, PLC firmware, PLC program), data preservation in case of power breakdown
/tmp	8192 kByte	RAM disk, suitable as intermediate buffer for FTP downloads, but no data preservation in case of power breakdown
/var	1024 kByte	RAM disk which is used by the system to store temporary files, no data preservation in case of power breakdown
/mnt		Target for integrating remote directories, it is not part of the PLCcore-5484 standard functionality

Sizes of file system paths that are configured or still available can be identified by using the Linux command "df" ("DiskFree") – see Figure 7.

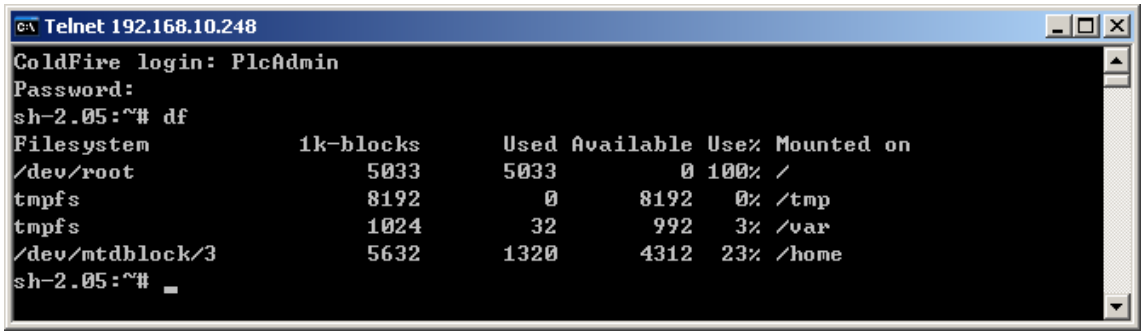
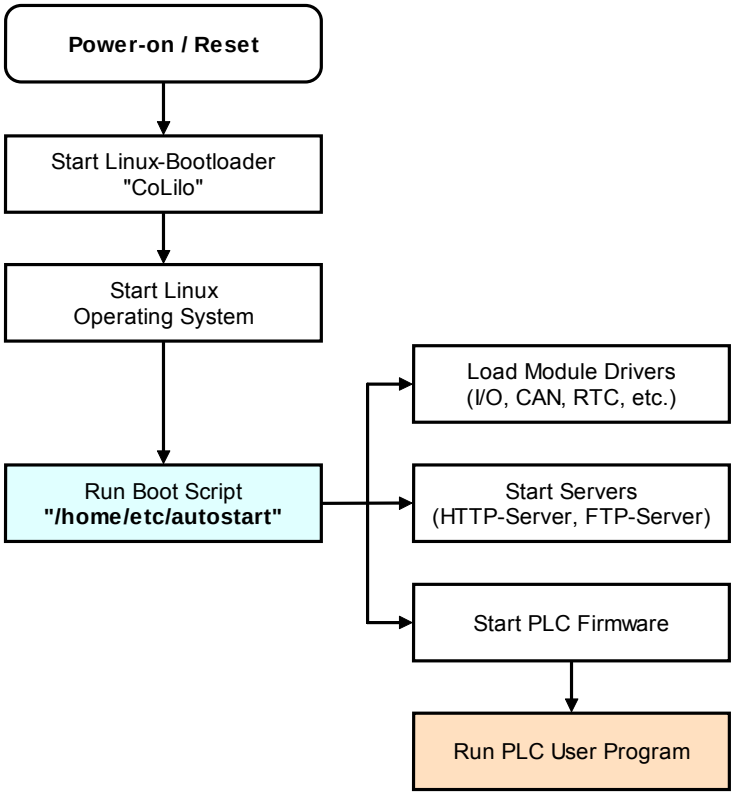

Telnet 192.168.10.248
ColdFire login: PlcAdmin
Password:
sh-2.05:~# df
Filesystem 1k-blocks Used Available Use% Mounted on
/dev/root 5033 5033 0 100% /
tmpfs 8192 0 8192 0% /tmp
tmpfs 1024 32 992 3% /var
/dev/mtdblock/3 5632 1320 4312 23% /home
sh-2.05:~#

Figure 7: Display of information about the file system

Particular information about the system login and handling the Linux command shell of the PLCcore-5484 is given attention in section 6.

4.4 System start of the PLCcore-5484

By default, the PLCcore-5484 loads all necessary firmware components upon Power-on or Reset and starts running the PLC program afterwards. Hence, the PLCcore-5484 is suitable for the usage in autarchic control systems. In case of power breakdown, such systems resume the execution of the PLC program independently and without user intervention. Figure 8 shows the system start in detail:


Power-on / Reset
Start Linux-Bootloader "CoLilo"
Start Linux Operating System
Run Boot Script "/home/etc/autostart"
Load Module Drivers (I/O, CAN, RTC, etc.)
Start Servers (HTTP-Server, FTP-Server)
Start PLC Firmware
Run PLC User Program

For more details on how to deactivate the autarchic Linux start and to activate the “CoLilo" command prompt compare section 5.1.

Details about the start script **"/home/etc/autostart"** are covered in section 5.4.

For detailed information about PLC programming of the PLCcore-5484 compare section 4.5.

Figure 8: System start of the PLCcore-5484

4.5 Programming the PLCcore-5484

The PLCcore-5484 is programmed with IEC 61131-3-conform *OpenPCS* programming environment. There exist additional manuals about *OpenPCS* that describe the handling of this programming tool. Those are part of the software package. All manuals relevant for the PLCcore-5484 are listed in Table 3.

PLCcore-5484 firmware is based on standard firmware for SYS TEC`s compact control units. Consequently, it shows identical properties like other SYS TEC control systems. This affects especially the process image setup (see section 4.6) as well as the functionality of control elements (Hex-Encoding switch, DIP switch, Run/Stop switch, Run-LED, Error-LED).

Depending on the firmware version used, PLCcore-5484 firmware provides numerous function blocks to the user to access communication interfaces. Table 8 specifies the availability of FB communication classes (SIO, CAN, UDP) for different PLCcore-5484 firmware versions. Section 5.5 describes the selection of the appropriate firmware version.

Table 8: Support of FB communication classes for different types of the PLCcore

Type of Interface	PLCcore-5484/Z3 Art. no: 3390000	PLCcore-5484/Z4 Art. no: 3390004	PLCcore-5484/Z5 Art. no: 3390005	Remark
CAN	-	x	X	FB description see manual L-1008
UDP	-	x	X	FB description see manual L-1054
SIO	x	x	X	FB description see manual L-1054

4.6 Process image setup

Compared to other SYS TEC compact control systems, the PLCcore-5484 obtains a process image with identical addresses. All in- and outputs listed in Table 9 are supported by the PLCcore-5484.

Table 9: Assignment of in- and outputs to the process image of the PLCcore-5484

I/O of PLCcore-5484 or Kit	Name of I/O for Process Image	Process Image Address
DI0 ... DI7	DI0 ... DI7	%IB0.0
DI8 ... DI15	DI8 ... DI15	%IB1.0
DI16 … DI23	DI16 … DI23	%IB20.0
ADC of Demoboard (Kit)	AI0	%IW40.0
On-board Temperature Sensor	TMP0	%ID72.0
DO0 ... DO7	DO0 ... DO7	%QB0.0
DO8 … DO15	DO8 … DO15	%QB1.0
DO16 … DO21	DO16 … DO21	%QB2.0

Advice: The PLCcore-5484 works with Big-Endian format ("Motorola-Notation"). Consequently and on the contrary to controls using Little-Endian format ("Intel-Notation"), it is **not possible** to sum up several BYTE variables of the process image to one WORD or DWORD and to access Bits above Bit7. The following example shows issue described:

```
bInByte0  AT %IB0.0 : BYTE;
bInByte1  AT %IB1.0 : BYTE;
wInWord   AT %IW0.0 : BYTE;

wInWord.0 <> bInByte0.0      due to Big-Endian:  wInWord.0 == bInByte1.0
wInWord.8 <> bInByte1.0      due to Big-Endian:  wInWord.8 == bInByte0.0
```

In- and outputs of thePLCcore-5484 are not negated in the process image. Hence, the H-level at one input leads to value "1" at the corresponding address in the process image. Contrariwise, value "1" in the process image leads to an H-level at the appropriate output.

Network variables of CAN1 interface are designed into the process image marker section according to the following assignment:

CAN1_IN0	%MB0.0
...	...
CAN1_IN240	%MB240.0
CAN1_OUT0	%MB256.0
...	...
CAN1_OUT240	%MB496.0

Network variables of CAN0 interface are dynamically designed via DCF file of the control and are referred to as *"VAR_EXTERNAL"* in the PLC program. Details are described in the *"User Manual CANopen extension for IEC 61131-3"* (Manual no: L-1008).

4.7 Control and display elements

4.7.1 Run/Stop switch

Module connections *"PLD_IO32"*, *"PLD_IO33"* and *"PLD_IO34"* (see Table 5 and see reference design in Appendix A) are designed to connect a Run/Stop switch. Using this Run/Stop switch makes it possible to start and interrupt the execution of the PLC program. Together with start and stop pushbuttons of the OpenPCS programming environment, the Run/Stop switch represents a "logical" AND-relation. This means that the PLC program will not start the execution until the local Run/Stop switch is positioned to *"Run"* **AND** additionally the start command (cold, warm or hot start) is given by the OpenPCS user interface. The order hereby is not relevant. A run command given by OpenPCS while at the same time the Run/Stop switch is positioned to *"Stop"* is visible through quick flashing of the Run-LED (green).

Positioned to *"MRes"* (*"Modul Reset"*), the Run/Stop switch allows for local deletion of a PLC program from the PLCcore-5484. This might for example be necessary if an error occurs and the PLC program is running an infinite loop and consequently, accessing the OpenPCS programming environment is no longer possible. The procedure for deleting a PLC program is described in section 4.8.

4.7.2 Run-LED (green)

The module connection *"/Run-LED"* (see Table 5 and reference design in Appendix A) is designed for connecting a Run-LED. This Run-LED provides information about the activity state of the control system. The activity state is shown through different modes:

Table 10: Display status of the Run-LED

LED Mode	PLC Activity State
Off	The PLC is in state *"Stop"*: • the PLC does not have a valid program, • the PLC has received a stop command from the *OpenPCS* programming environment or • the execution of the program has been canceled due to an internal error
Quick flashing in relation 1:8 to pulse	The PLC is on standby but is not yet executing: • The PLC has received a start command from the *OpenPCS* programming environment but the local Run/Stop switch is still positioned to *"Stop"*
Slow flashing in relation 1:1 to pulse	The PLC is in state *"Run"* and executes the PLC program.
Quick flashing in relation 1:1 to pulse	The PLC is in mode *"Reset"*, compare section 4.8

4.7.3 Error-LED (red)

Module connection *"/Error-LED"* (see Table 5 and reference design in Appendix A) is designed for connecting an Error-LED. This Error-LED provides information about the error state of the control system. The error state is represented through different modes:

Table 11: Display status of the Error-LED

LED Mode	PLC Error State
Off	No error has occurred; the PLC is in normal state.
Permanent light	A severe error has occurred: • The PLC was started using an invalid configuration (e.g. CAN node address 0x00) and had to be stopped or • A severe error occurred during the execution of the program and caused the PLC to independently stop its state *"Run"* (division by zero, invalid Array access, ...), see below
Slow flashing in relation 1:1 to pulse	A network error occurred during communication to the programming system; the execution of a running program is continued. This error state will be reset independently by the PLC as soon as further communication to the programming system is successful.
Quick flashing in relation 1:1 to pulse	The PLC is in mode *"Reset"*, compare section 4.8.
Quick flashing in relation 1:8 to pulse	The PLC is on standby, but is not yet running: • The PLC has received a start command from the *OpenPCS* programming environment but the local Run/Stop switch is positioned to *"Stop"*

In case of severe system errors such as division by zero of invalid Array access, the control system passes itself from state *"Run"* into state *"Stop"*. This is recognizable by the permanent light of the

Error-LED (red). In this case, the error cause is saved by the PLC and is transferred to the computer and shown upon next power-on.

4.8 Local deletion of a PLC program

If the Run/Stop switch is positioned to *"MRes"* (*"Modul Reset"*) (see section 4.7.1), it is possible to delete a program from the PLCcore-5484. This might for example be necessary if an error occurs and the PLC program is running an infinite loop and consequently, accessing the OpenPCS programming environment is no longer possible. To prevent deleting a PLC program by mistake, it is necessary to keep to the following order:

(1) Position the Run/Stop switch to *"MRes"*

(2) Reset the PLCcore-5484 (by pressing the reset pushbutton of the Development Board or through temporary power interrupt)
⇨ Run-LED (green) is flashing quickly in relation 1:1 to the pulse

(3) Position the Run/Stop switch to *"Run"*
⇨ Error-LED (red) is flashing quickly in relation 1:1 to the pulse

(4) Reposition Run/Stop switch back to *"MRes"* **within 2 seconds**
⇨ PLCcore-5484 is deleting PLC program
⇨ Run-LED (green) and Error-LED (red) are both flashing alternately

(5) Reposition Run/Stop switch to *"Stop"* or *"Run"* and reset again to start the PLCcore-5484 and bring it into normal working state

If Reset of the PLCcore-5484 is activated (e.g. through temporary power interrupt) while at the same time the Run/Stop switch is positioned to *"MRes"*, the module recognizes a reset requirement. This is visible through quick flashing of the Run-LED (green). This mode can be stopped without risk. Therefore, the Run/Stop switch must be positioned to *"Run"* or *"Stop"* (Error-LED is flashing) and it must be waited for 2 seconds. The PLCcore-5484 independently stops the reset process after 2 seconds and starts a normal working state with the PLC program which was saved last.

5 Configuring the PLCcore-5484

5.1 Activation/Deactivation of Linux Autorun

During standard operation mode, the bootloader "CoLilo" automatically starts the Linux operating system of the module after Reset (or Power-on). Afterwards, the operating system loads all further software components und controls the PLC program execution (see section 4.4). For service purposes, such as configuring the Ethernet interface (see section 5.2) or updating the Linux image (see section 6.7.2), it is necessary to disable this Autorun mode and to switch to "CoLilo" command prompt instead (configuration mode).

The automatic boot of Linux operating system is connected with the **simultaneous compliance** with various conditions ("AND relation"). Consequently, for disabling Linux Autorun, it is sufficient to simply **not comply** with one of the conditions.

Table 12 lists up all conditions that are verified by the bootloader “CoLilo”. All of them must be complied with to start an Autorun for the Linux image.

Table 12: Conditions for booting Linux

No.	Conditions	Remark
1	*"kfl=1"* and *"auto=1"*	The Linux image stored in the Flash must be declared as valid during CoLilo configuration and the Autorun of the image must be activated after Reset (for respective CoLilo commands see section 6.7.2)
2	DIP2 of PLCcore-5484 = "On" or Connection "/BOOT" = GND	DIP-Switch 2 on the PLCcore-5484 and module connection "/BOOT" are electrically connected in parallel. The position of DIP-Switch 2 on the PLCcore-5484 is shown in Figure 9, the position of connection "/BOOT" on the module pin connector is defined in Table 5.
3	**No** interruption of Autorun via COM0 of the PLCcore-5484	If all conditions are complied with, CoLilo verifies the serial interface COM0 of the PLCcore-5484 for about 1 second after Reset regarding the reception of SPACE signals (ASCII 20H). If such a signal is received within that time, CoLilo will disable the Linux Autorun and will activate its own command prompt instead.

According to Table 12, the Linux boot is disabled after Reset (e.g. pushbutton S303 on the Development Board) and the CoLilo command prompt is activated instead if the following conditions occur:

(1) DIP2 = "Off" and /BOOT = "High" DIP2: see Figure 9, /BOOT: see Table 5, DIP2 and "/BOOT" are connected in parallel

- OR -

(2) Reception of a SPACE signal (ASCII 20H) within 1 second after Reset

After activating the Reset pushbutton (e.g. S303 on the Development Board), the "CoLilo" command prompt answers.

Figure 9 shows the positioning and meaning of DIP-Switch 2 on the PLCcore-5484. This DIP-Switch might be hard to access if the module is built in. Thus, the Portpin of the processor that is connected to the switch is available as connection "/BOOT" on the pin connector of the PLCcore-5484 (see Table 5).

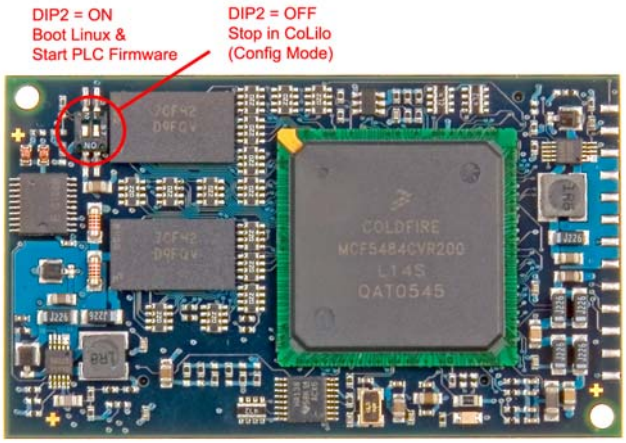


Figure 9: Positioning and meaning of the DIP-Switch 2 on the PLCcore-5484

Communicating with the bootloader "CoLilo" only takes place via the serial interface COM0 of the PLCcore-5484. As a receiver on the PC one of the terminal programs must be started (e.g. HyperTerminal or TeraTerm, see section 6.1) and must be configured as follows (see Figure 10):

- 19200 Baud
- 8 Data bit
- 1 Stop bit
- no parity
- no flow control

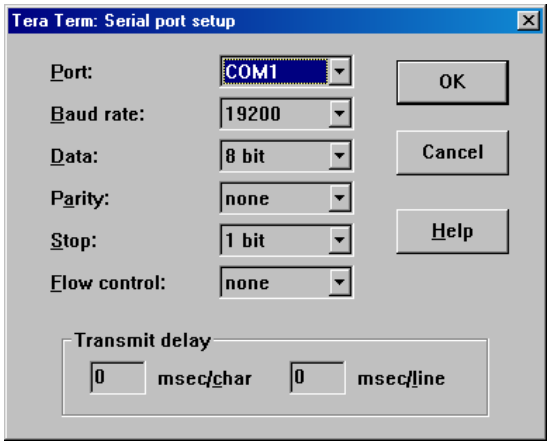


Figure 10: Terminal configuration using the example of "TeraTerm"

5.2 Ethernet configuration of the PLCcore-5484

The main Ethernet configuration of the PLCcore-5484 takes place within the bootloader "CoLilo" and is taken on for all software components (Linux, PLC firmware, HTTP server etc.). The Ethernet configuration is carried out via the serial interface COM0. **Therefore, the CoLilo command prompt must be activated as described in section 5.1** Table 13 lists up CoLilo commands necessary for the Ethernet configuration of the PLCcore-5484.

Table 13: "CoLilo" configuration command of the PLCcore-5484

Configuration	Command	Remark
MAC address	set mac <xx:xx:xx:xx:xx:xx>	The MAC address worldwide is a clear identification oft he module and is assigned by the producer. **It should not be modified by the user.**
IP address	set ip <xxx.xxx.xxx.xxx>	This command sets the local IP address of the PLCcore-5484. The IP address is to be defined by the network administrator.
Network mask	set netmask <xxx.xxx.xxx.xxx>	This command sets the network mask of the PLCcore-5484. The network mask is to be defined by the network administrator.
Gateway address	set gw <xxx.xxx.xxx.xxx>	This command defines the IP address of the gateway which is to be used by the PLCcore-5484. The gateway address is set by the network administrator. **Advice:** If PLCcore-5484 and Programming PC are located within the same sub-net, defining the gateway address may be skipped and value "0.0.0.0" may be used instead.
Saving the configuration	config save	This command saves active configurations in the flash of the PLCcore-5484.

Modified configurations may be verified again by entering "*?*" in the "CoLilo" command prompt. Active configurations are permanently saved in the Flash of the PLCcore-5484 by command

config save

Modifications are adopted upon next Reset of the PLCcore-5484.

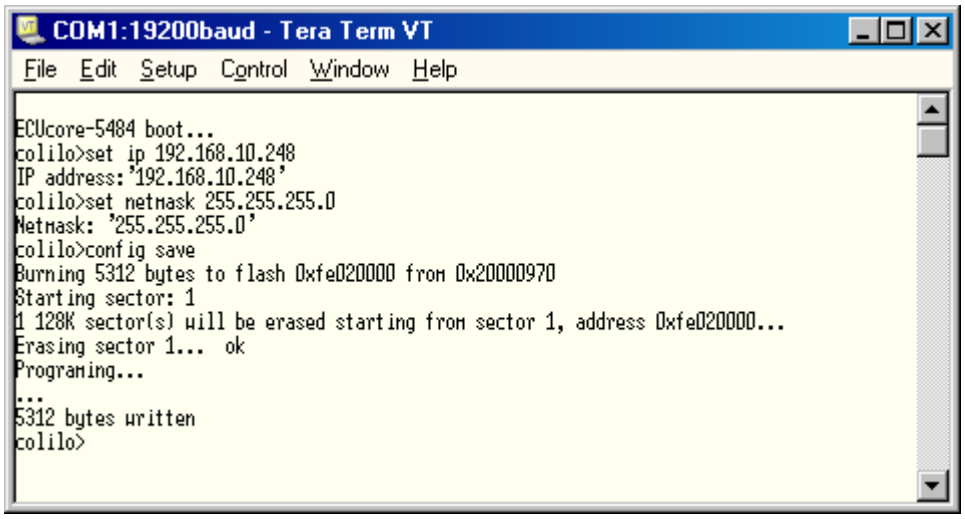


Figure 11: Ethernet configuration of the PLCcore-5484

After the configuration is finished and according to section 5.1, all conditions for a Linux Autorun must be re-established.

Upon Reset (e.g. pushbutton S303 on the Development Board) the module starts using the active configurations.

Advice: After the configuration is finished, the serial connection between PC and PLCcore-5484 is no longer necessary.

5.3 PLC configuration of the ECUcore-5484

5.3.1 PLC configuration via WEB-Frontend

After finishing the Ethernet configuration (see section 5.1), all further adjustments can take place via the integrated WEB-Frontend of the PLCcore-5484. For the application of the PLCcore-5484 using the Development Kit, basic configurations may also be set via local control elements (see section 5.3.2).

To configure the PLCcore-5484 via WEB-Frontend it needs a WEB-Browser on the PC (e.g. Microsoft Internet Explorer, Mozilla Firefox etc.). To call the configuration page, prefix *"http://"* must be entered into the address bar of the WEB-Browser prior to entering the IP address of the PLCcore-5484 as set in section 5.1, e.g. *"http://192.168.10.248"*. Figure 12 exemplifies calling the PLCcore-5484 configuration page in the WEB-Browser.

The standard setting (factory setting) requires a user login to configure the PLCcore-5484 via WEB-Frontend. This is to prevent unauthorized access. Therefore, user name and password must be entered (see Figure 12). On delivery of the module, the following user account is preconfigured (see section 6.2):

User: PlcAdmin
Password: Plc123

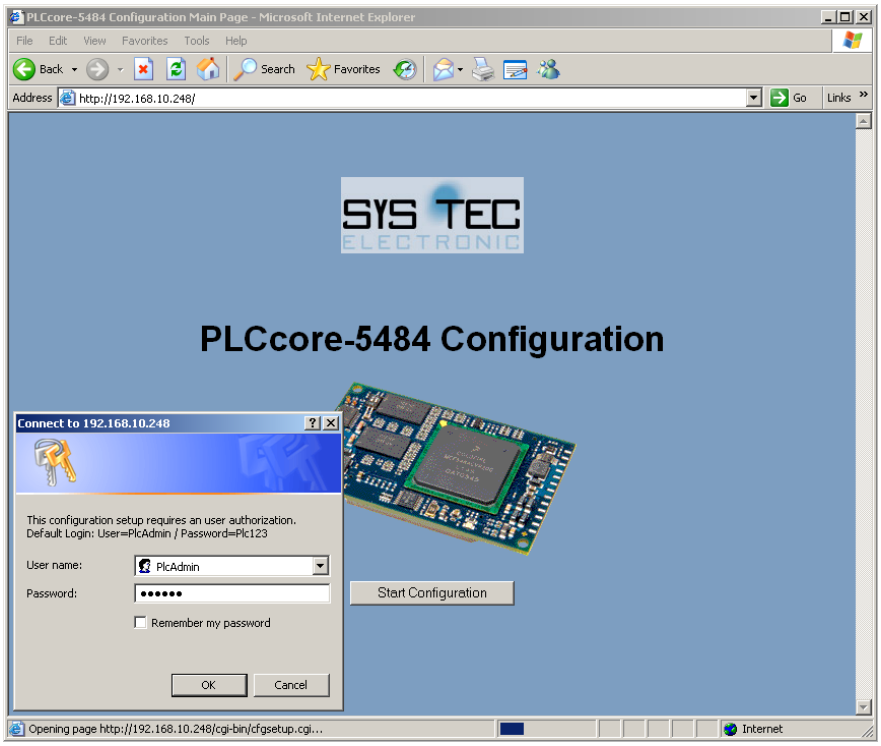


Figure 12: User login dialog of the WEB-Frontend

All configuration adjustments for the PLCcore-5484 are based on dialogs. They are adopted into the file **"/home/plc/plccore-5484.cfg"** of the PLCcore-5484 by activating the pushbutton "Save Configuration" (also compare section 5.3.3). After activating Reset (e.g. pushbutton S303 on the Development Board), the PLCcore-5484 starts automatically using the active configuration. Figure 13 shows the configuration of the PLCcore-5484 via WEB-Frontend.

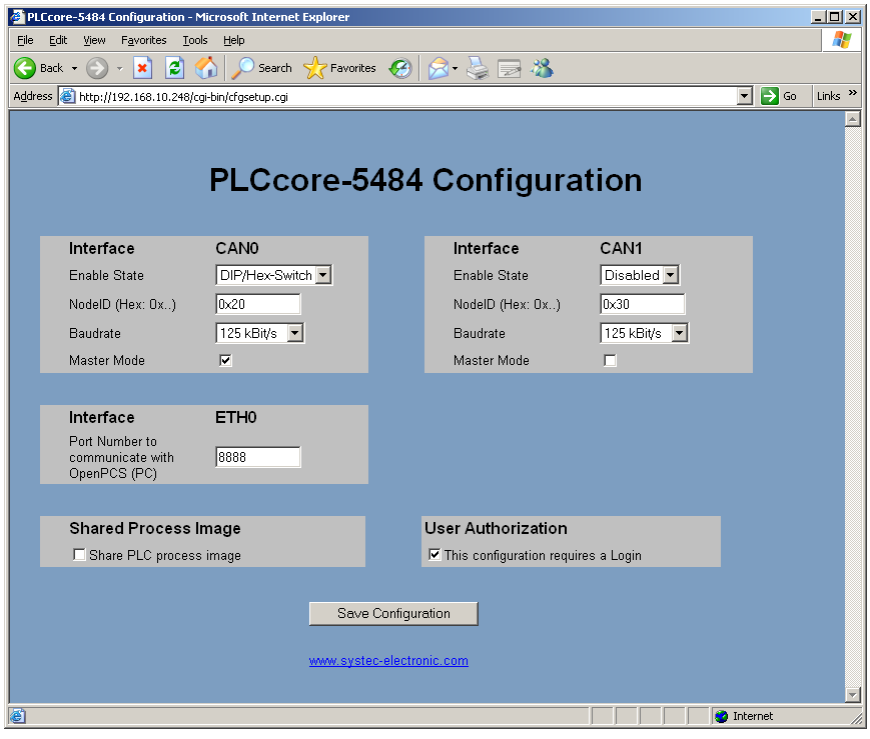


Figure 13: PLC configuration via WEB-Frontend

If "DIP/Hex-Switch" is chosen as Enable State of Interface CAN0, the configuration of this interface takes place via local control elements of the Development Kit PLCcore-5484 (see section 5.3.2).

The standard setting (factory setting) of the PLCcore-5484 requires a user login to access the WEB-Frontend. Therefore, only the user name indicated in configuration file **"/home/plc/plccore-5484.cfg"** is valid (entry *"User="* in section *"[Login]"*, see 5.3.3). Procedures to modify the user login password are described in section 6.5. To allow module configuration to another user, an appropriate user account is to be opened as described in section 6.4. Afterwards, the new user name must be entered into the configuration file **"/home/plc/plccore-5484.cfg"**. Limiting the user login to one user account is cancelled by deleting the entry *"User="* in section *"[Login]"* (see 5.3.3). Thus, any user account may be used to configure the module. By deactivating control box *"This configuration requires a Login"* in the field *"User Authorization"* of the configuration page (see Figure 13), free access to the module configuration is made available without previous user login.

5.3.2 PLC configuration via control elements of the Development Kit PLCcore-5484

The configuration via control elements of the PLCcore-5484 Development Board **is preset upon delivery of the Development Kit PLCcore-5484.** This allows for an easy commissioning of the module by using CAN interface CAN0. Due to a limited number of switch elements, the initial setting of CAN0 is restricted. Using interface CAN1 requires a configuration via WEB-Frontend as described in section 5.3.1. This allows for other adjustments as well.

Advice: **Configuring interface CAN0 is only possible via local control elements if "DIP/Hex-Switch" is activated as Enable State for CAN0 via WEB-Frontend (factory setting). Otherwise, configurations made via WEB-Frontend take priority over those via control elements.**

Node address CAN0: The node address for interface CAN0 is set via Hex-Encoding switches S306 and S307 on the Development Board for PLCcore-5484:

S307: High part of the node address
S306: Low part of the node address

Example: S307=2 / S306=0 → resulting node address = 20 Hex.

Bitrate CAN0: The bitrate for interface CAN0 is adjusted via bit positions 1-3 of DIP switch S309 on the Development Board for PLCcore-5484. Table 14 lists the coding of bitrates supported.

Table 14: Setting the bitrate for CAN0 via DIP switch

Bitrate [kBit/s]	DIP1	DIP2	DIP3
10	OFF	OFF	ON
20	ON	OFF	OFF
50	ON	OFF	ON
125	OFF	OFF	OFF
250	OFF	ON	ON
500	OFF	ON	OFF
800	ON	ON	ON
1000	ON	ON	OFF

Master mode CAN0: The Master mode is activated via Bit position 4 of DIP switch S309 on the Development Board for PLCcore-5484:

DIP4 = OFF: PLC is NMT-Slave
DIP4 = ON: PLC is NMT-Master

5.3.3 Setup of the configuration file "plccore-5484.cfg"

The configuration file **"/home/plc/plccore-5484.cfg"** allows for comprehensive configuration of the PLCcore-5484. Although, working in it manually does not always make sense, because most of the adjustments may easily be edited via WEB-Frontend (compare section 5.3.1). The setup of the configuration file is similar to the file format "Windows INI-File". It is divided into "*[Sections]*" which include different entries "*Entry=*". Table 15 shows all configuration entries. Entries of section "*[CAN0]*" take priority over settings via control elements (see section 5.3.2).

Table 15: Configuration entries of the CFG file

Section	Entry	Value	Meaning
[CAN0]	Enabled	-1, 0, 1	-1: Interface CAN0 is activated, configuration takes place via control elements of the Development Board (factory setting, see section 5.3.2) 0: Interface CAN0 is deactivated 1: Interface CAN0 is activated, configuration takes place via entries of the configuration file below
	NodeID	1 … 127 or 0x01 … 0x7F	Node number for interface CAN0 (decimal or hexadecimal with prefix "0x")
	Baudrate	10, 20, 50, 125, 250, 500, 800, 1000	Bitrate for interface CAN0
	MasterMode	0, 1	1: Master mode is activated 0: Master mode is deactivated
[CAN1]	Enabled	0, 1	0: Interface CAN1 is deactivated 1: Interface CAN1 is activated, configuration takes place via entries of the configuration file below
	NodeID	1 … 127 or 0x01 … 0x7F	Node number for interface CAN1 (decimal or hexadecimal with prefix "0x")
	Baudrate	10, 20, 50, 125, 250, 500, 800, 1000	Bitrate for interface CAN1
	MasterMode	0, 1	1: Master mode is activated 0: Master mode is deactivated
[ETH0]	PortNum	Default Port no: 8888	Port number for the communication with the Programming-PC and for program download (only for PLCcore-5484/Z5, order number 3390005)
[Extensions]	ShPImgEnable	0, 1	0: No sharing of process image 1: Sharing of process image is enabled

			(see section 7.1)
[Login]	Authorization	0, 1	0: Configuration via WEB-Frontend is possible without user login 1: Configuration via WEB-Frontend requires user login
	User	Default Name: PlcAdmin	If entry "User=" is available, only the user name defined is accepted for the login to configure via WEB-Frontend. If the entry is not available, any user registered on the PLCcore-5484 (see section 6.4) may login via WEB-Frontend.

The configuration file **"/home/plc/plccore-5484.cfg"** includes the following factory settings:

```
[Login]
Authorization=1
User=PlcAdmin

[CAN0]
Enabled=-1
NodeID=0x20
Baudrate=125
MasterMode=1

[CAN1]
Enabled=0
NodeID=0x30
Baudrate=125
MasterMode=0

[ETH0]
PortNum=8888

[Extensions]
ShPImgEnable=0
```

5.4 Boot configuration of the PLCcore-5484

The PLCcore-5484 is configured so that after Reset the PLC firmware starts automatically. Therefore, all necessary commands are provided by the start script **"/home/etc/autostart"**. Hence, the required environment variables are set and drivers are booted.

If required, the start script **"/home/etc/autostart"** may be complemented by further entries. For example, by entering command *"ftpd -D"*, the FTP server is called automatically when the PLCcore-5484 is booted. The script can be edited directly on the PLCcore-5484 in the FTP client *"WinSCP"* (compare section 6.1) using pushbutton *"F4"* or *"F4 Edit"*.

5.5 Selecting the appropriate firmware version

The PLCcore-5484 is delivered with different firmware versions. Those vary in the communication protocol for the data exchange with the programming PC and they differ from each other regarding the availability of FB communication classes (see section 4.5). The selection of the appropriate firmware version takes place in the start script ***"/home/etc/autostart"***. By default, the *"BoardID"* of the module

as set in the bootloader "CoLilo" is analyzed. Table 16 lists up the assignments of firmware versions and BoardIDs.

Table 16: Assignment of BoardIDs and firmware versions for the PLCcore-5484

BoardID	Firmware Version	Remark
1005004	plccore-5484-z4	**PLCcore-5484/CANopen** communication with the programming PC via CANopen protocol (Interface CAN0)
1005005	plccore-5484-z5	**PLCcore-5484/Ethernet** communication with the programming PC via UDP protocol (Interface ETH0)

The configuration of BoardIDs takes place via the serial interface COM0. **Therefore, the CoLilo command prompt must be activated as described in section 5.1.** Setting BoardIDs is carried out via the CoLilo command *"assign boardid"* by entering the corresponding number listed in Table 16, e.g.:

```
assign  boardid  1005005
```

The modified setting can be verified by entering "*boardinfo*" at the "CoLilo" command prompt. Command

config save

persistently saves the current selection in the Flash of the PLCcore-5484. Figure 14 visualizes the configuration of the BoardID.

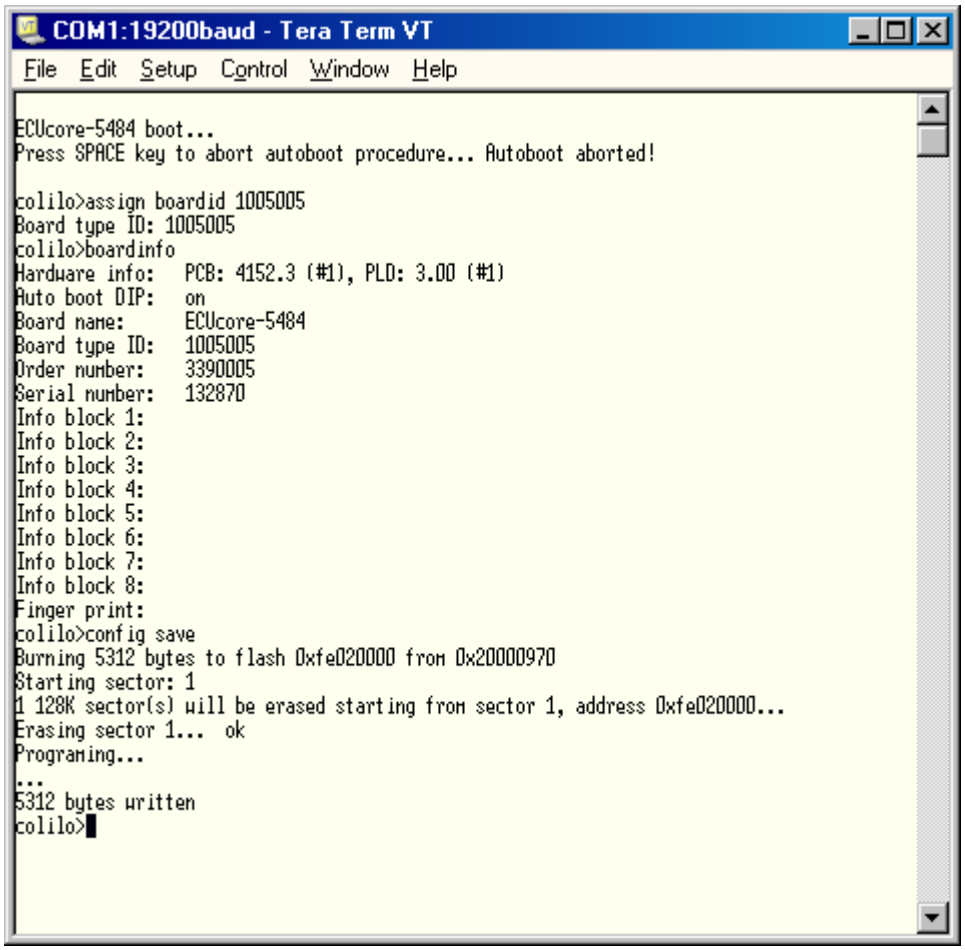


Figure 14: Selecting the appropriate firmware version for the PLCcore-5484

After completing the configuration, all preconditions for a Linux autostart must be reestablished according to section 5.1.

Alternatively, the appropriate firmware version may be selected directly in the start script ***"/home/etc/autostart"***. Therefore, delete part "Select PLC Type" and insert the appropriate firmware instead, e.g.:

```
PLC_FIRMWARE=$PLC_DIR/plccore-5484-z5
```

6 Administration of the PLCcore-5484

6.1 System requirements and necessary software tools

The administration of the PLCcore-5484 requires any Windows or Linux computer that has available an Ethernet interface and a serial interface (RS232). As alternative solution to the on-board serial interface, SYS TEC offers a USB-RS232 Adapter Cable (order number 3234000, see section 3.4.2) that provides an appropriate RS232 interface via USB port.

All examples referred to in this manual are based on an administration of the PLCcore-5484 using a Windows computer. Procedures using a Linux computer would be analogous.

To administrate the PLCcore-5484 the following software tools are necessary:

Terminal program

A Terminal program allows the communication with the **Command Shell** of the PLCcore-5484 via a **serial RS232 connection to COM0 of the PLCcore-5484**. This is required for the Ethernet configuration of the PLCcore-5484 as described in section 5.1. After finishing the Ethernet configuration, all further commands can either be entered in the Terminal program or alternatively in a Telnet client (see below).

Suitable as Terminal program would be *"HyperTerminal"* which is included in the Windows delivery or *"TeraTerm"* which is available as Open Source and meets higher demands (download from: http://ttssh2.sourceforge.jp).

Telnet client

Telnet-Client allows the communication with **command shell** of the PLCcore-5484 via an **Ethernet connection to ETH0 of the PLCcore-5484**. Using Telnet clients requires a completed Ethernet configuration of the PLCcore-5484 according to section 5.1. As alternative solution to Telnet client, all commands can be edited via a Terminal program (to COM0 of the PLCcore-5484).

Suitable as Telnet client would be *"Telnet"* which is included in the Windows delivery or *"TeraTerm"* which can also be used as Terminal program (see above).

FTP client

An FTP client allows for file exchange between the PLCcore-5484 (ETH0) and the computer. This allows for example **editing configuration files** by transferring those from the PLCcore-5484 onto the computer where they can be edited and get transferred back to the PLCcore-5484. Downloading files onto the PLCcore-5484 is also necessary to **update the PLC firmware**. (Advice: The update of *PLC firmware* is not identical with the update of the *PLC user program*. The PLC program is directly transferred to the module from the OpenPCS programming environment. No additional software is needed for that.)

Suitable as FTP client would be *"WinSCP"* which is available as Open Source (download from: http://winscp.net). It only consists of one EXE file that needs no installation and can be booted immediately. Furthermore, freeware *"Core FTP LE"* (download from: http://www.coreftp.com) or *"Total Commander"* (integrated in the file manager) are suitable as FTP client.

TFTP server The TFTP server is necessary to update the Linux image on the PLCcore-5484. Freeware *"TFTPD32"* (download from: http://tftpd32.jounin.net) is suitable as TFTP server. It only consists of one EXE file that needs no installation and can be booted immediately.

For programs that communicate via Ethernet interface, such as FTP client or TFTP server, it must be paid attention to that rights in the Windows-Firewall are released. Usually Firewalls signal when a program seeks access to the network and asks if this access should be permitted or denied. In this case access is to be permitted.

6.2 Predefined user accounts

All user accounts listed in Table 17 are predefined upon delivery of the PLCcore-5484. Those allow for a login to the command shell (serial RS232 connection or Telnet) and at the FTP server of the PLCcore-5484.

Table 17: Predefined user accounts of the PLCcore-5484

User name	Password	Remark
PlcAdmin	Plc123	Predefined user account for the administration of the PLCcore-5484 (configuration, user administration, software updates etc.)
root	Sys123	Main user account ("root") of the PLCcore-5484

6.3 Login to the PLCcore-5484

6.3.1 Login to the command shell

In some cases the administration of the PLCcore-5484 requires the entry of Linux commands in the command shell. Therefore, the user must be directly logged in at the module. There are two different possibilities:

- Logging in is possible with the help of a **Terminal program** (e.g. HyperTerminal or TeraTerm, see section 6.1) via the serial interface **COM0** of the PLCcore-5484 – analog to the procedure described for the Ethernet configuration in section 5.1. **For the configuration of the terminal settings pay attention to only use "CR" (carriage return) as end-of-line character.** Login with user name and password is not possible for "CR+LF" (carriage return + line feed)!

- Alternatively, the login is possible using a **Telnet client** (e.g. Telnet or also TeraTerm) via the Ethernet interface **ETH0** of the PLCcore-5484.

For logging in to the PLCcore-5484 via the Windows standard Telnet client, the command "*telnet*" must be called by using the IP address provided in section 5.1, e.g.

```
telnet  192.168.10.248
```

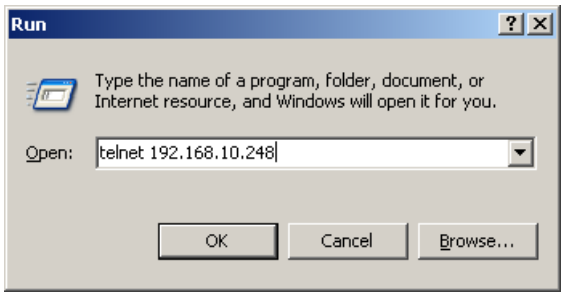


Figure 15: Calling the Telnet client in Windows

Logging in to the PLCcore-5484 is possible in Terminal window (if connected via COM0) or Telnet window (if connected via ETH0). The following user account is preconfigured for the administration of the module upon delivery of the PLCcore-5484 (also compare section 6.2):

User: *PlcAdmin*
Password: *Plc123*

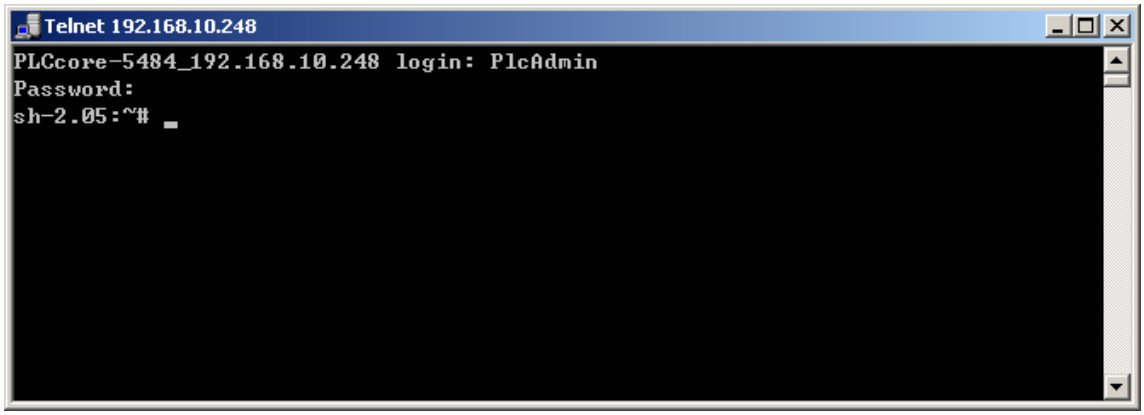


Figure 16: Login to the PLCcore-5484

Figure 16 illustrates a login to the PLCcore-5484 using a Windows standard Telnet client.

6.3.2 Login to the FTP server

The PLCcore-5484 has available a FTP server (FTP Deamon) that allows file exchange with a computer (up- and download of files). Due to security and performance reasons, the FTP server is deactivated by default and must be started manually if required. Therefore, the user must first be logged in to the command shell of the PLCcore-5484 following the procedures described in section 6.3.1. Afterwards, the following command must be entered in the Telnet or Terminal window:

```
ftpd  -D
```

Figure 17 illustrates an example for starting the FTP server.

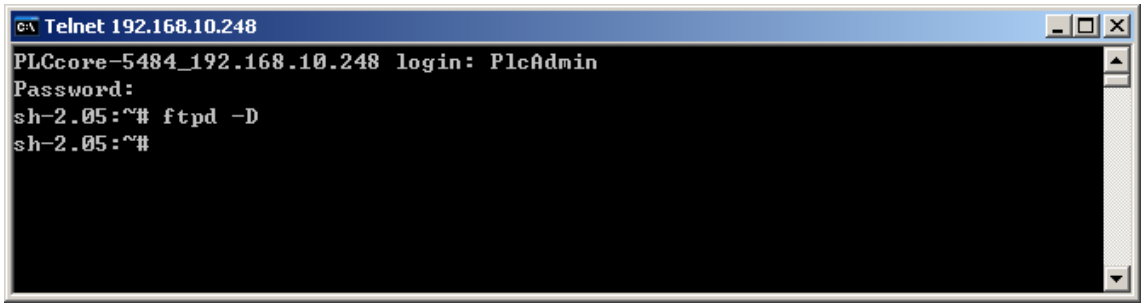


Figure 17: Starting the FTP server

Advice: By entering command *"ftpd -D"* in the start script **"/home/etc/autostart"**, calling the FTP server upon boot of the PLCcore-5484 may be automated (see section 5.4).

"WinSCP" which is available as open source would be suitable as FTP client for the computer (see section 6.1). It consists of only one EXE file, needs no installation and may be started immediately. After program start, dialog *"WinSCP Login"* appears (see Figure 18) and must be adjusted according to the following configurations:

File protocol: FTP
Host name: IP address for the PLCcore-5484 as set in section 5.1
User name: *PlcAdmin* (for predefined user account, see section 6.2)
Password: *Plc123* (for predefined user account, see section 6.2)

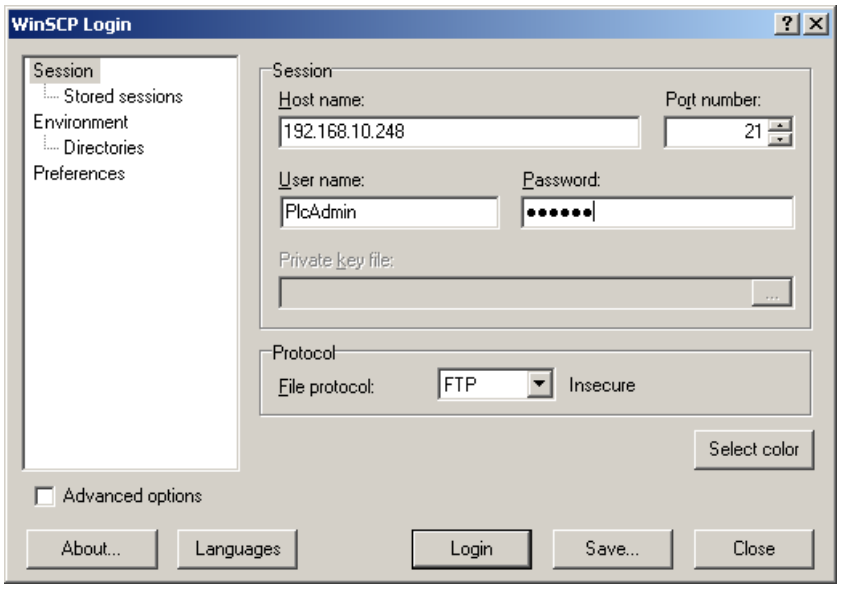


Figure 18: Login configurations for WinSCP

After using pushbutton *"Login"*, the FTP client logs in to the PLCcore-5484 and lists up the active content of directory *"/home"* in the right window. Figure 19 shows FTP client *"WinSCP"* after successful login to the PLCcore-5484.

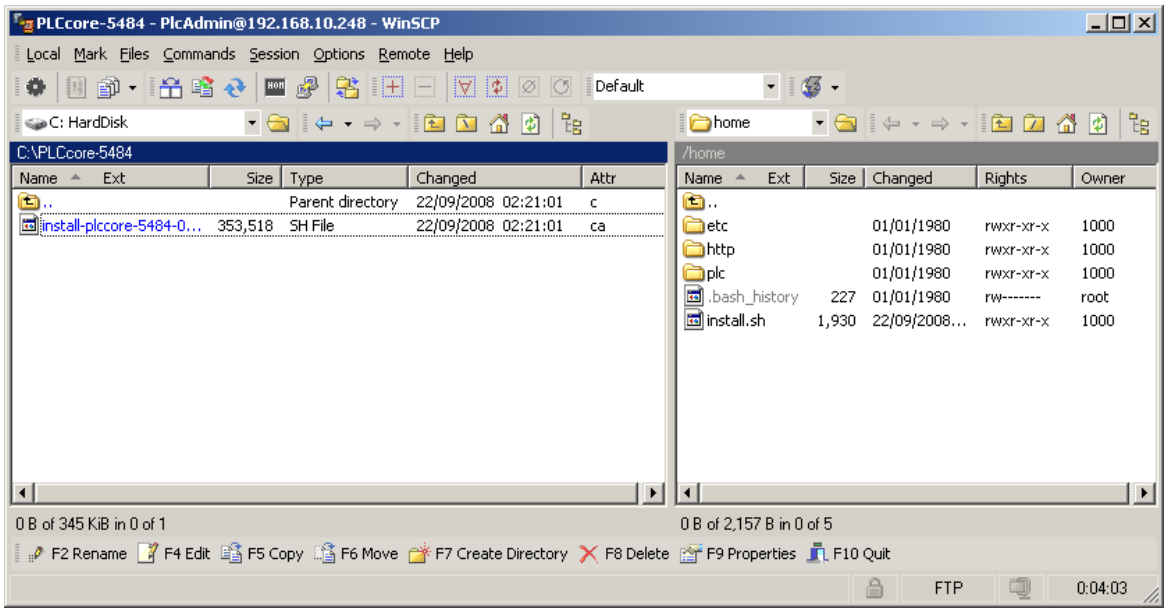

PLCcore-5484 - PlcAdmin@192.168.10.248 - WinSCP
Local Mark Files Commands Session Options Remote Help
Default
C: HardDisk
home
C:\PLCcore-5484
/home
Name Ext Size Type Changed Attr
.. Parent directory 22/09/2008 02:21:01 c
install-plccore-5484-0... 353,518 SH File 22/09/2008 02:21:01 ca
Name Ext Size Changed Rights Owner
..
etc 01/01/1980 rwxr-xr-x 1000
http 01/01/1980 rwxr-xr-x 1000
plc 01/01/1980 rwxr-xr-x 1000
.bash_history 227 01/01/1980 rw------- root
install.sh 1,930 22/09/2008... rwxr-xr-x 1000
0 B of 345 KiB in 0 of 1
0 B of 2,157 B in 0 of 5
F2 Rename F4 Edit F5 Copy F6 Move F7 Create Directory F8 Delete F9 Properties F10 Quit
FTP
0:04:03

Figure 19: FTP client for Windows "WinSCP"

After successful login, configuration files on the PLCcore-5484 may be edited by using pushbuttons *"F4"* or *"F4 Edit"* within the FTP client *"WinSCP"* (select transfer mode *"Text"*). With the help of pushbutton *"F5"* or *"F5 Copy"*, files may be transferred between the computer and the PLCcore-5484, e.g. for data backups of the PLCcore-5484 or to transfer installation files for firmware updates (select transfer mode *"Binary"*).

6.4 Adding and deleting user accounts

Adding and deleting user accounts requires the login to the PLCcore-5484 as described in section 6.3.1.

Adding a new user account takes place via Linux command *"adduser"*. In embedded systems such as the PLCcore-5484, it does not make sense to open a directory for every user. Hence, parameter *"-H"* disables the opening of new directories. By using parameter *"-h /home"*, the given directory *"/home"* is rather assigned to the new user. To open a new user account on the PLCcore-5484, Linux command *"adduser"* is to be used as follows:

```
adduser -h /home -H -G <group> <username>
```

Figure 20 exemplifies the adding of a new account on the PLCcore-5484 for user *"admin2"*.

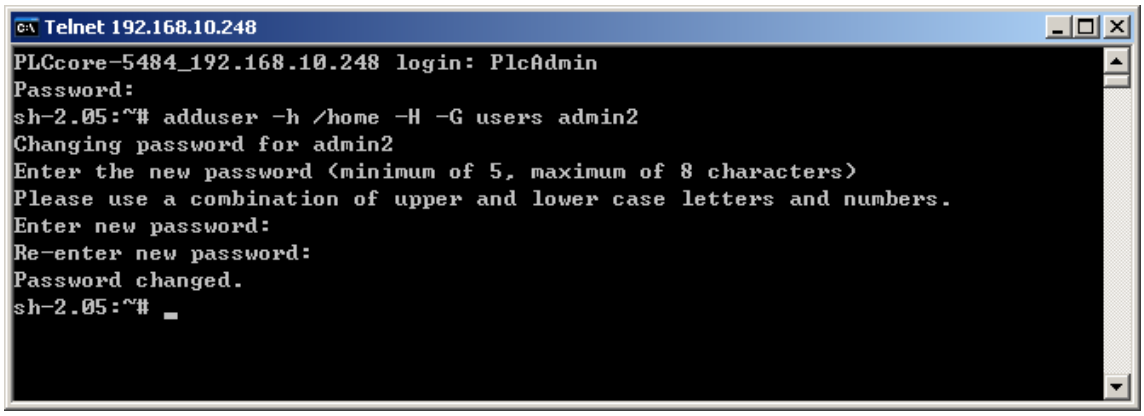

Telnet 192.168.10.248
PLCcore-5484_192.168.10.248 login: PlcAdmin
Password:
sh-2.05:~# adduser -h /home -H -G users admin2
Changing password for admin2
Enter the new password (minimum of 5, maximum of 8 characters)
Please use a combination of upper and lower case letters and numbers.
Enter new password:
Re-enter new password:
Password changed.
sh-2.05:~#

Figure 20: Adding a new user account

Advice:	**If the new user account shall be used to access WEB-Frontend, the user name must be entered into the configuration file *"plccore-5484.cfg"* (for details about logging in to WEB-Frontend please compare section 5.3.1 and 5.3.3).**

To **delete** a user account from the PLCcore-5484, the Linux command *"deluser"* plus the respective user name must be used:

```
deluser <username>
```

6.5 How to change the password for user accounts

Changing the password for user accounts requires login to the PLCcore-5484 as described in section 6.3.1.

To change the password of any user account on the PLCcore-5484, Linux command *"passwd"* plus the respective user name must be entered:

```
passwd <username>
```

Figure 21 exemplifies the password change for user *"PlcAdmin"*.

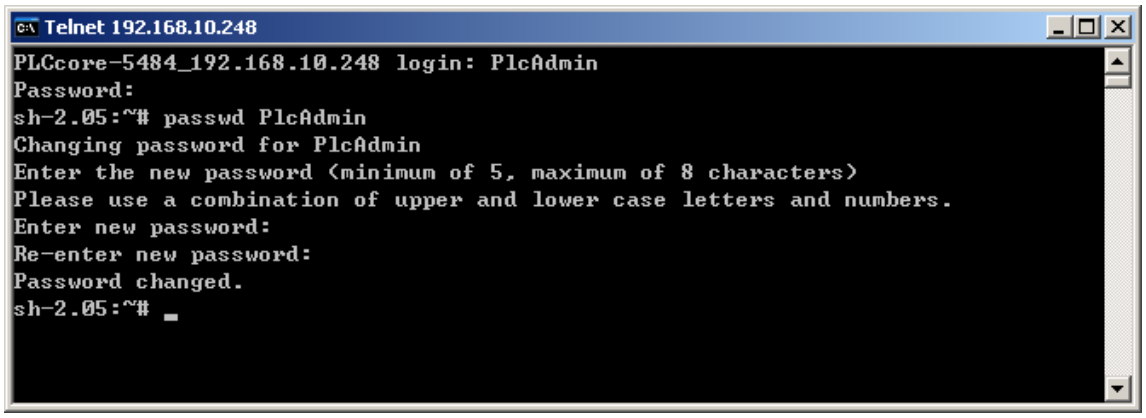

Telnet 192.168.10.248
PLCcore-5484_192.168.10.248 login: PlcAdmin
Password:
sh-2.05:~# passwd PlcAdmin
Changing password for PlcAdmin
Enter the new password (minimum of 5, maximum of 8 characters)
Please use a combination of upper and lower case letters and numbers.
Enter new password:
Re-enter new password:
Password changed.
sh-2.05:~#

Figure 21: Changing the password of a user account

6.6 Setting the system time

Setting the system time requires login to the PLCcore-5484 as described in section 6.3.1.

There are two steps for setting the system time of the PLCcore-5484. At first, the current date and time must be set using Linux command *"date"*. Afterwards, by using Linux command *"hwclock -w"* the system time is taken over into RTC module of the PLCcore-5484.

Linux command *"date"* is structured as follows:

```
date [options] [MMDDhhmm[[CC]YY][.ss]]
```

Example:

```
date   09 22 10 20 2008.55
        |  |  |  |     |  |
        |  |  |  |     |  +--- second
        |  |  |  |     +------ year
        |  |  |  +------------ minute
        |  |  +--------------- hour
        |  +------------------ day
        +--------------------- month
```

Spaces in the parameter list are only inserted to present the example above clearly. All spaces do not apply when the command is actually used. To set the system time of the PLCcore-5484 to 2008/09/22 and 10:20:55 (as shown in the example above), the following commands are necessary:

```
date 092210202008.55
hwclock -w
```

The current system time is displayed by entering Linux command *"date"* (without parameter). Linux command *"hwclock -r"* can be used to recall current values from the RTC. Figure 22 exemplifies setting and displaying the system time.

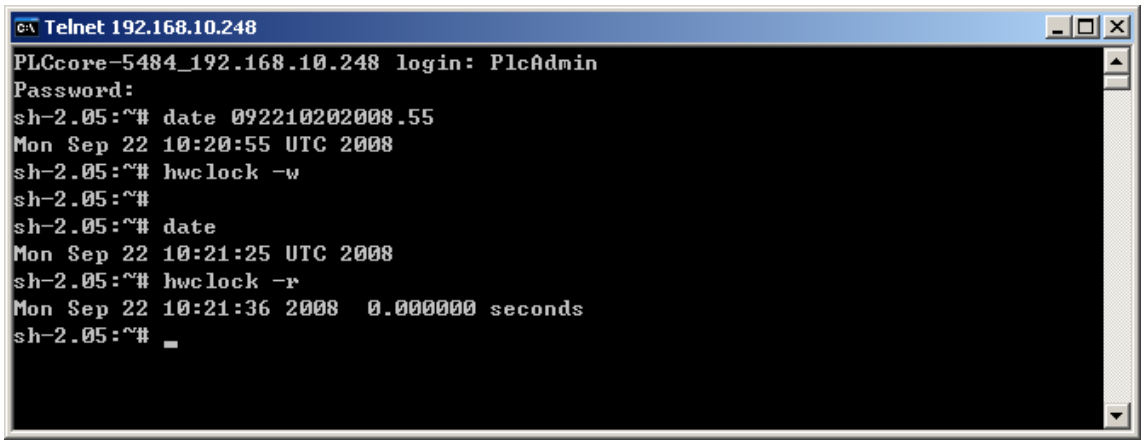


Figure 22: Setting and displaying the system time

Upon start of the PLCcore-5484, date and time are taken over from the RTC and set as current system time of the module. Therefore, Linux command *"hwclock -r"* is necessary which is included in start script **"etc/rc.d/rc.modules"**.

6.7 Software update of the PLCcore-5484

All necessary firmware components to run the PLCcore-5484 are already installed on the module upon delivery. Hence, firmware updates should only be required in exceptional cases, e.g. to input new software that includes new functionality.

6.7.1 Updating the PLC firmware

PLC firmware indicates the run time environment of the PLC. ***PLC firmware*** can only be generated and modified by the producer; **it is not identical with the PLC user program** which is created by the PLC user. The PLC user program is directly transferred from the OpenPCS programming environment onto the module. No additional software is needed.

Updating the PLC firmware requires login to the command shell of the PLCcore-5484 as described in section 6.3.1 and login to the FTP server as described in section 6.3.2.

Updating the PLC firmware takes place via a self-extracting firmware archive that is transferred onto the PLCcore-5484 via FTP. After starting the FTP server on the PLCcore-5484 (command *"ftpd -D"*, see section 6.3.2), the respective firmware archive can be transferred into directory *"/tmp"* of the PLCcore-5484 (see Figure 23).

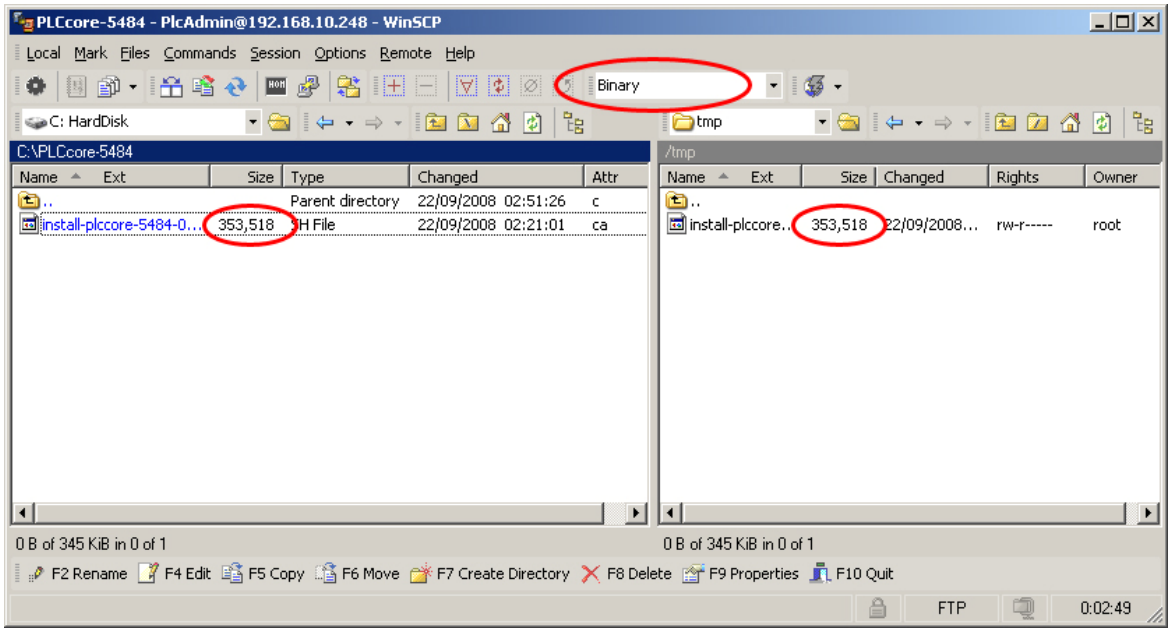

PLCcore-5484 - PlcAdmin@192.168.10.248 - WinSCP
Local Mark Files Commands Session Options Remote Help
Binary
C: HardDisk
tmp
C:\PLCcore-5484
/tmp
Name Ext Size Type Changed Attr
.. Parent directory 22/09/2008 02:51:26 c
install-plccore-5484-0... 353,518 SH File 22/09/2008 02:21:01 ca
Name Ext Size Changed Rights Owner
.. install-plccore... 353,518 22/09/2008... rw-r----- root
0 B of 345 KiB in 0 of 1
0 B of 345 KiB in 0 of 1
F2 Rename F4 Edit F5 Copy F6 Move F7 Create Directory F8 Delete F9 Properties F10 Quit
FTP
0:02:49

Figure 23: File transfer in FTP client "WinSCP"

Important: To transfer the firmware archive via FTP, transfer type *"Binary"* must be chosen. If FTP client *"WinSCP"* is used, the appropriate transfer mode is to be chosen from the menu bar. After downloading the firmware archive, it must be checked if the file transferred to the PLCcore-5484 has the exact same size as the original file on the computer (compare Figure 23). Any differences in that would indicate a mistaken transfer mode (e.g. *"Text"*). In that case the transfer must be repeated using transfer type *"Binary"*.

After downloading the self-extracting archive, the PLC firmware must be installed on the PLCcore-5484. Therefore, the following commands are to be entered in the Telnet window. It must be considered that the file name for the firmware archive is labeled with a version identifier (e.g. "install-plccore-5484-0402_0100.sh" for version 4.02.01.00). This number must be adjusted when commands are entered:

```
cd /tmp
chmod +x install-plccore-5484-0402_0100.sh
./install-plccore-5484-0402_0100.sh
```

Advice: The command shell of the PLCcore-5484 is able to automatically complete names if the tab key is used. Hence, it should be sufficient to enter the first letters of each file name and the system will complement it automatically. For example, *"./ins"* is completed to *"./install-plccore-5484-0402_0100.sh"* if the tab key is used.

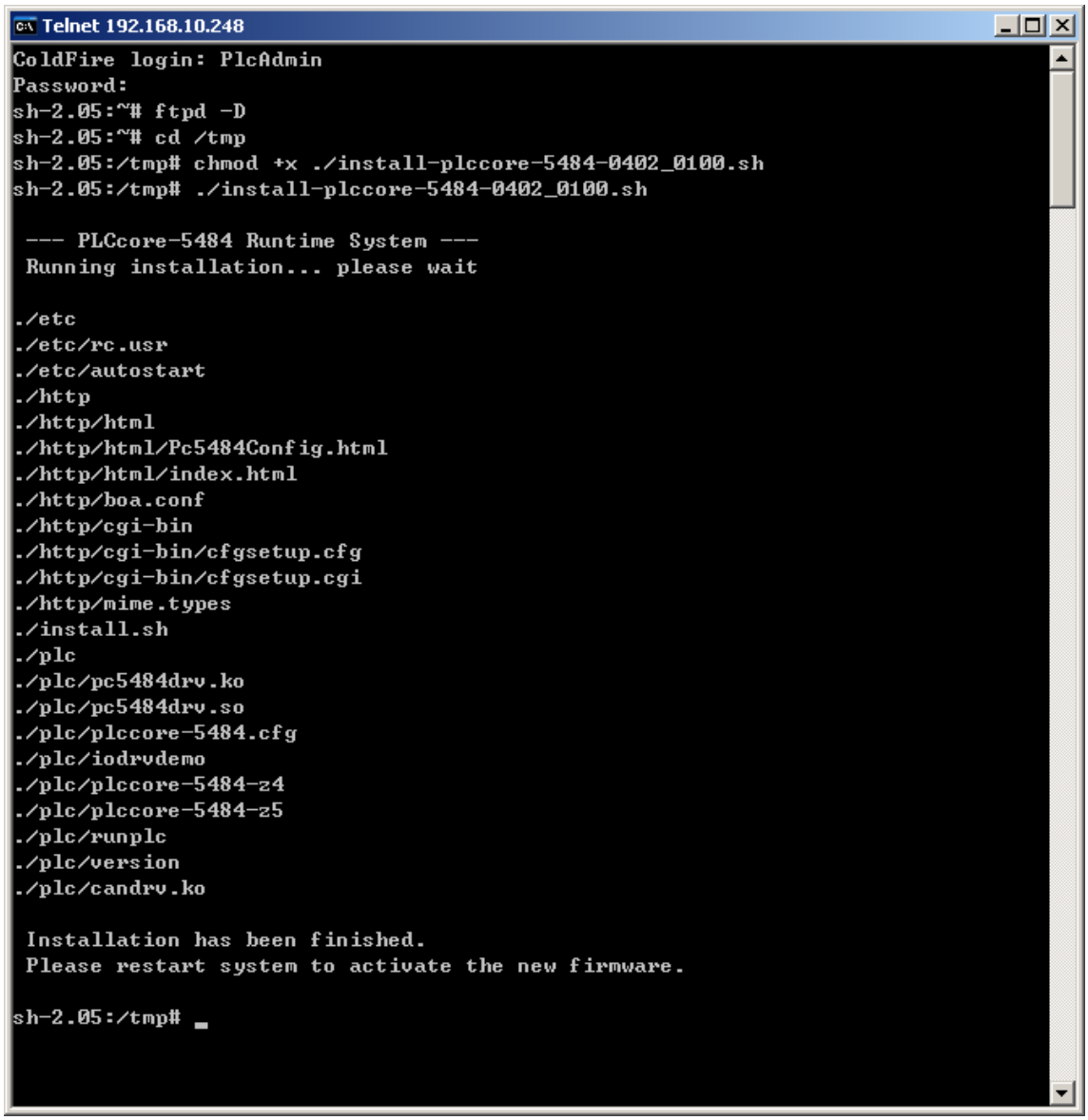


Figure 24: Installing PLC firmware on the PLCcore-5484

Figure 24 exemplifies the installation of PLC firmware on the PLCcore-5484. After Reset the module is started using the updated firmware.

6.7.2 How to update the Linux image

Updating the Linux image takes place via TFTP (**T**rivial **FTP**) within Linux bootloader *"CoLilo"*. Therefore, an appropriate TFTP server is necessary on the computer, e.g. freeware *"TFTPD32"* (compare section 6.1). The program consists of only one EXE file that requires no installation and can be run immediately. After the program start, an appropriate working directory ("Current Directory") should be created by clicking on pushbutton *"Browse"* (e.g. *"C:\PLCcore-5484"*). The Linux image for the PLCcore-5484 must be located in this directory (*image.bin.gz*).

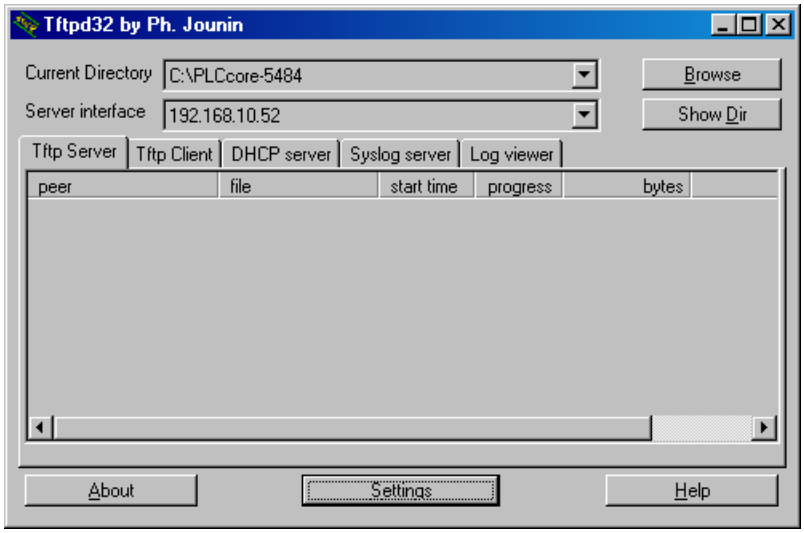


Figure 25: TFTP server for Windows "TFTPD32"

A TFTP download of the Linux image **requires** that the **Ethernet configuration** of the PLCcore-5484 is **completed** according to procedures describes in **section 5.2**. To update the Linux image it is necessary to have available another serial connection to the PLCcore-5484 in addition to the Ethernet connection. All configurations for the terminal program as described in section 5.1 apply (19200 Baud, 8 Data bit, 1 Stop bit, no parity and no flow control).

Updating the Linux image of the PLCcore-5484 is only possible if Linux is not running. Hence, Linux Autorun must be disabled prior to the updating process and "CoLilo" command prompt must be used instead. Procedures are described in section 5.1.

After Reset (e.g. pushbutton S303 on the Development Board), the "CoLilo" command prompt answers. To update the Linux images the following commands must be entered according to the following sequence:

Table 18: Command sequence to update the Linux image on the PLCcore-5484

Command	Meaning
set server <host_ip_addr>	Setting the IP address of the TFTP server. If *"TFTPD32"* is used, the address is shown in field "Server Interface" on the PC.
set image image.bin.gz	Setting the file names for the Linux image to be loaded
tftp 0xC2000000	Downloading the Linux image from the PC to the PLCcore-5484
flash 0xFE040000	Saving the Linux image in the Flash of the PLCcore-5484
set kfl 1	To validate the Linux image stored in the Flash of the PLCcore-5484
set auto 1	Autorun of the Linux image after Reset is activated
config save	Saving the current configurations in the Flash

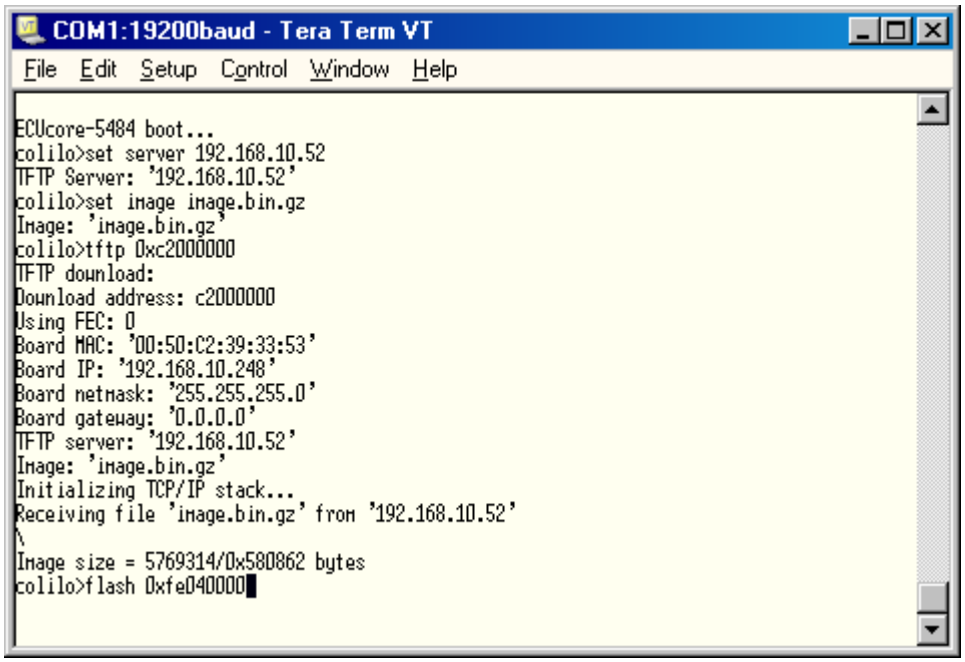


Figure 26: Downloading the Linux image to the PLCcore-5484

After completing the configuration, conditions for a Linux Autorun must be reestablished according to instructions in section 5.1.

After Reset is activated (e.g. pushbutton S303 on the Development Board), the PLCcore-5484 starts automatically using the current Linux image.

Advice: After the configuration is finished, the serial connection between the computer and the PLCcore-5484 is no longer necessary.

7 Adaption of In-/Outputs and Process Image

7.1 Data exchange via shared process image

7.1.1 Overview of the shared process image

The PLCcore-5484 is based on the operating system Embedded Linux. Thus, it is possible to execute other user-specific programs simultaneously to running the PLC firmware. The PLC program and a user-specific C/C++ application can exchange data by using the same process image (shared process image). Implementing user-specific C/C++ applications **is based on the Software package SO-1095 ("VMware-Image of the Linux development system")**.

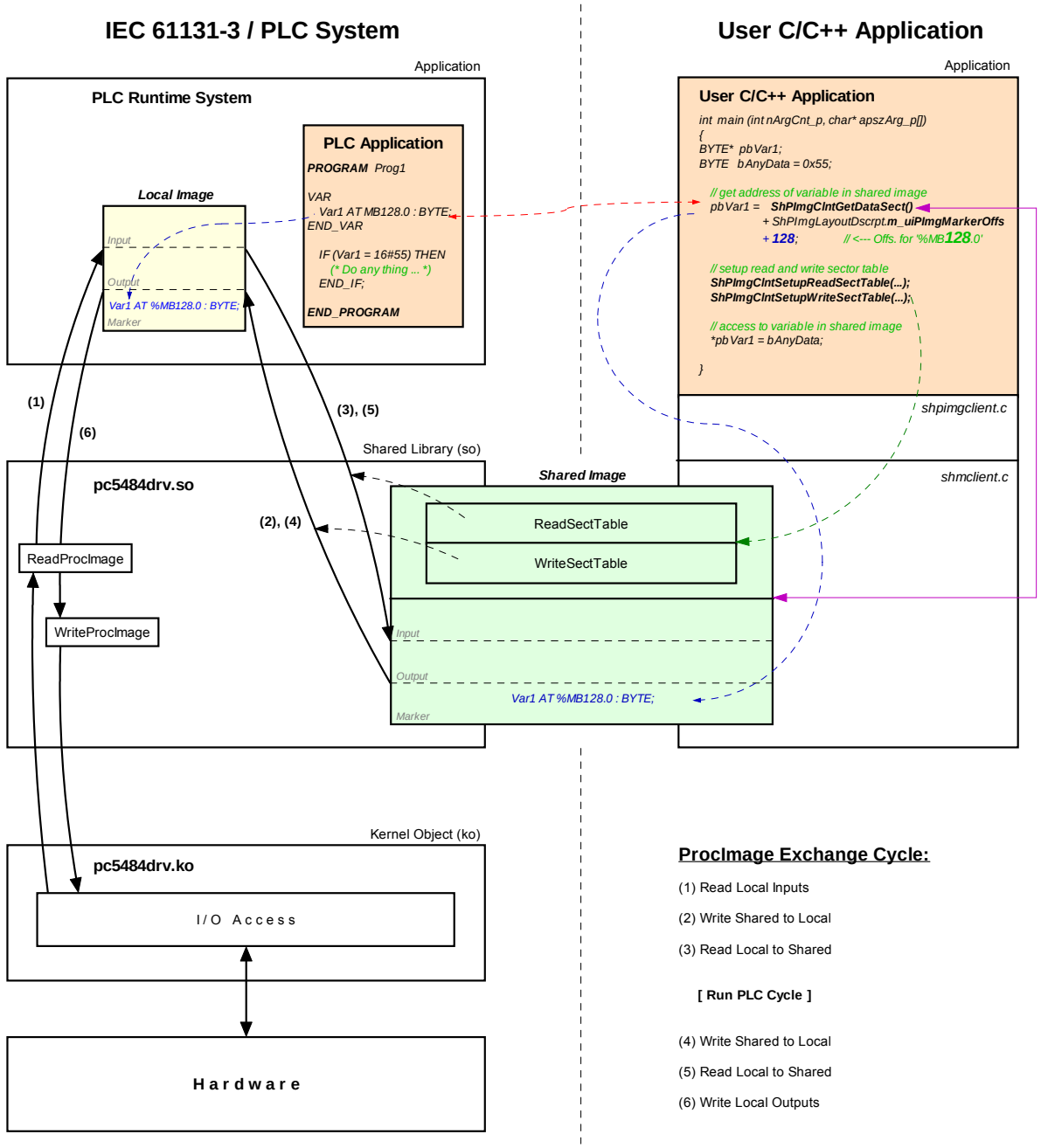


Figure 27: Overview of the shared process image

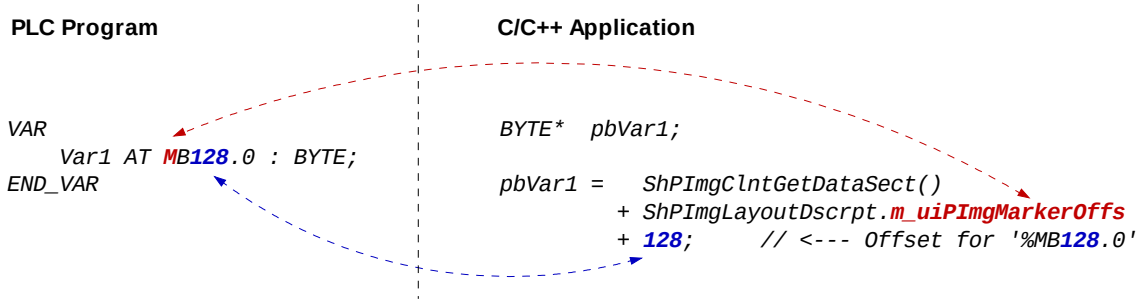
Not all variables are utilizable via the shared process image within a C/C++ application. Only those directly addressed variables that the PLC program generates within the process image. As shown in Figure 27, two separate process images are used for the data exchange with an external application inside of the PLC runtime system. This is necessary to meet the IEC 61131-3 requirement that the initial PLC process image may not be modified during the entire execution of one PLC program cycle. Thereby, the PLC program always operates with the internal process image that is locally generated within the PLC runtime system ("Local Image" in Figure 27). This is integrated within the PLC runtime system and is protected against direct accesses from the outside. On the contrary, the user-specific, external C/C++ application always uses the shared process image ("Shared Image" in Figure 27). This separation of two process images enables isolation between accesses to the PLC program and the external application. Those two in parallel and independently running processes now must only be synchronized for a short period of time to copy the process data.

An activation of **option *"Shared process image"*** within the PLC configuration enables data exchange with external applications (see section 5.3.1). Alternatively, entry *"ShPImgEnable="* can directly be set within section *"[Extensions]"* of the configuration file **"/home/plc/plccore-5484.cfg"** (see section 5.3.3). The appropriate configuration setting is evaluated upon start of the PLC firmware. By activating option *"Shared process image"*, the PLC firmware creates a second process image as Shared Memory ("Shared Image" in Figure 27). Its task is to exchange data with external applications. Hereby, the PLC firmware functions as Server and the external, user-specific C/C++ application functions as Client.

ReadSectorTable and ***WriteSectorTable*** both control the copying of data between the two process images. Both tables are filled by the Client (external, user-specific C/C++ application) and are executed by Server (PLC runtime system). The Client defines ranges of the PLC process image from which it will read data (*ReadSectorTable*) or in which it will write data (*WriteSectorTable*). Hence, the terms *"Read"* and *"Write"* refer to data tranfer directions from the viewpoint of the Client.

Sections to read and write may comprise all sections of the entire process image – input, output as well as marker sections. This allows for example that a Client application writes data into the input section of the PLC process image and reads data from the output section. Figure 27 shows the sequence of single read and write operations. Prior to the execution of a PLC program cycle, the physical inputs are imported into the local process image of the PLC (1). Afterwards, all sections defined in *WriteSectorTable* are taken over from the shared process image into the local process image (2). By following this sequence, a Client application for example is able to overwrite the value of a physical input. This may be used for simulation purposes as well as for setting input data to constant values (*"Forcen"*). Similarly, prior to writing the process image onto the physical outputs (6), sections defined in *WriteSectorTable* are taken over from the shared process image into the local process image. (4). Thus, a Client application is able to overwrite output information generated by the PLC program.

The PLC firmware provides the **setup of the process image**. The Client application receives information about the setup of the process image via function ***ShPImgCIntSetup()***. This function enters start offsets and values of the input, output and marker sections into the structure of type *tShPImgLayoutDscrpt*. Function ***ShPImgCIntGetDataSect()*** provides the start address of the shared process image. Upon defining a variable within the PLC program, its absolute position within the process image is determined through sections (%I = Input, %Q = Output, %M = Merker) and offset (z.B. %MB**128**.0). In each section the offset starts at zero, so that for example creating a new variable in the merker section would be independent of values in the input and output section. Creating a corresponding **pair of variables** in the PLC program as well as in the C/C++ application allows for data exchange between the PLC program and the external application. Therefore, both sides must refer to the same address. Structure *tShPImgLayoutDscrpt* reflects the physical setup of the process image in the PLC firmware including input, ouput and marker sections. This is to use an addressing procedure for defining appropriate variables in the C/C++ application that is comparable to the PLC program. Hence, also in the C/C++ program a variable is defined in the shared process image by indicating the respective section and its offset. The following example illustrates the creation of a corresponding variable pair in the PLC program and C/C++ application:



As described above, ***ReadSectorTable*** and ***WriteSectorTable*** manage the copy process to exchange variable contents between the PLC and the C/C++ program. Following the example illustrated, the Client (C/C++ application) must enter an appropriate value into the *WriteSectorTable* to transfer the value of a variable from the C/C++ application to the PLC program (*WriteSectorTable*, because the Client "writes" the variable to the Server):

```
// specify offset and size of 'Var1' and define sync type (always or on demand?)
WriteSectTab[0].m_uiPImgDataSectOffs = ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 128;
WriteSectTab[0].m_uiPImgDataSectSize = sizeof(BYTE);
WriteSectTab[0].m_SyncType           = kShPImgSyncOnDemand;

// define the WriteSectorTable with the size of 1 entry
ShPImgCntSetupWriteSectTable (WriteSectTab, 1);
```

If several variable pairs are generated within the same transfer direction for the data exchange between the PLC program and the C/C++ application, they should possibly all be defined in one coherent address range. Thus, it is possible to list them as one entry in the appropriate SectorTable. The address of the first variable must be set as the *SectorOffset* and the sum of the variable sizes as *SectorSize*. Combining the variables improves the efficiency and the performance of the copy processes.

For each entry of the *WriteSectorTable* an appropriate *SyncType* must be defined. It determines whether the section is generally taken over from the shared process image into the local image whenever there are two successive PLC cycles (***kShPImgSyncAlways***) or whether it is taken over on demand (***kShPImgSyncOnDemand***). If classified as *SyncOnDemand*, the data only is copied if the respective section before was explicitly marked as updated. This takes places by calling function ***ShPImgCntWriteSectMarkNewData()*** and entering the corresponding *WriteSectorTable*-Index (e.g. 0 for *WriteSectTab[0]* etc.).

kShPImgSyncAlways is provided as *SyncType* for the *ReadSectorTable* (the value of the member element *m_SyncType* is ignored). The PLC firmware is not able to identify which variables were changed by the PLC program of the cycle before. Hence, all sections defined in *ReadSectorTable* are always taken over from the local image into the shared process image. Thus, the respective variables in the shared process image always hold the actual values.

The PLC firmware and the C/C++ application both use the shared process image. To prevent conflicts due to accesses from both of those in parallel running processes at the same time, the shared process image is internally protected by a semaphore. If one process requires access to the shared process image, this process enters a critical section by setting the semaphore first and receiving exclusive access to the shared process image second. If the other process requires access to the shared process image at the same time, it also must enter a critical section by trying to set the semaphore. In this case, the operating system identifies that the shared process image is already being used. It blocks the second process until the first process leaves the critical section and releases the semaphore. Thereby, the operating system assures that only one of the two in paralell running processes (PLC runtime system and C/C++ application) may enter the critical section and receives access to the shared process image. To ensure that both processes do not interfere with each other too much, they should enter the critical section as less as possible and only as long as necessary. Otherwise, the PLC cycle time may be extended and runtime variations (Jitter) may occur.

The client application has available two functions to set the semaphore and to block exclusive access to the shared process image. Function ***ShPImgCIntLockSegment()*** is necessary to enter the critical section and function ***ShPImgCIntUnlockSegment()*** to leave it. The segment between both functions is called protected section, because in this segment the client application holds access to the shared process image without competition. The consistency of read or written data is only guaranteed within such a protected section. Outside the protected section, the shared process image may anytime be manipulated by the PLC runtime system. The following example shows the exclusive access to the shared process image in the C/C++ aplication:

```
ShPImgClntLockSegment();
{
    // write new data value into Var1
    *pbVar1 = bAnyData;

    // mark new data for WriteSectorTable entry number 0
    ShPImgClntWriteSectMarkNewData (0);
}
ShPImgClntUnlockSegment();
```

For the example above, *kShPImgSyncOnDemand* was defined as *SyncType* upon generating entry *WriteSectorTable*. Hence, taking over variable *Var1* from the shared process image into the local image can only take place if the respective section was beforehand explicitly marked as updated. Therefore, it is necessary to call function ***ShPImgCIntWriteSectMarkNewData()***. Since function *ShPImgCIntWriteSectMarkNewData()* does not modify the semaphore, it may only be used within a protected section (see example) – such as the code section between *ShPImgCIntLockSegment()* and *ShPImgCIntUnlockSegment()*.

The synchronisation between local image and shared process image by the PLC runtime system only takes place in-between two successive PLC cycles. A client application (user-specific C/C++ program) is not directly informed about this point of time, but it can get information about the update of the shared process image from the PLC runtime system. Therefore, the client application must define a callback handler of the type *tShPImgAppNewDataSigHandler*, e.g.:

```
static  void  AppSigHandlerNewData (void)
{
    fNewDataSignaled_l = TRUE;
}
```

This callback handler must be registered with the help of function ***ShPImgCIntSetNewDataSigHandler()***. The handler is selected subsequent to a synchronization of the two images.

The **callback handler of the client application is called within the context of a Linux signal handler** (the PLC runtime system informs the client using Linux function *kill()*). Accordingly, all common **restrictions** for the Linux signal handler also apply to the callback handler of the client application. In particular, it is only allowed to call a few operating system functions that are explicitly marked as reentrant-proof. Please pay attention to not make reentrant calls of local functions within the client applciation. As shown in the example, only a global flag should be set for the signalling within the callback handler. This flag will later on be evaluated and processed in the main loop of the client appliciation.

7.1.2 API of the shared process image client

As illustrated in Figure 27, the user-specific C/C++ application exclusively uses the API (Application Programming Interface) provided by the s*hared process image client*. This API is declared in the

header file *shpimgclient.h* and implemented in the source file *shpimgclient.c*. It contains the following types (partly defined in *shpimg.h*) and functions:

Structure *tShPImgLayoutDscrpt*

```
typedef struct
{
    // definition of process image sections
    unsigned int        m_uiPImgInputOffs;      // start offset of input section
    unsigned int        m_uiPImgInputSize;      // size of input section
    unsigned int        m_uiPImgOutputOffs;     // start offset of output section
    unsigned int        m_uiPImgOutputSize;     // size of output section
    unsigned int        m_uiPImgMarkerOffs;     // start offset of marker section
    unsigned int        m_uiPImgMarkerSize;     // size of marker section

} tShPImgLayoutDscrpt;
```

Structure ***tShPImgLayoutDscrpt*** describes the setup of the process image given by the PLC firmware. The client application receives the information about the setup of the process image via function *ShPImgClntSetup()*. This function enters start offsets and values of input, output and merker sections into the structure provided upon function calling.

Structure *tShPImgSectDscrpt*

```
typedef struct
{
    // definition of data exchange section
    unsigned int        m_uiPImgDataSectOffs;
    unsigned int        m_uiPImgDataSectSize;
    tShPImgSyncType     m_SyncType;              // only used for WriteSectTab
    BOOL                m_fNewData;

} tShPImgSectDscrpt;
```

Structure ***tShPImgSectDscrpt*** describes the setup of a *ReadSectorTable* or *WriteSectorTable* entry that must be defined by the client. Both tables support the synchronization between the local image of the PLC runtime system and the shared process image (see section 7.1.1). Member element *m_uiPImgDataSectOffs* defines the absolute start offset of the section within the shared process imagees. The respective start offsets of the input, output and merker sections can be determined through structure *tShPImgLayoutDscrpt*. Member element *m_uiPImgDataSectSize* determines the size of the section which may include one or more varaibles. Member element *m_SyncType* only applies to entries of the WriteSectorTable. It determines whether the section is generally taken over from the shared process image into the local image whenever there are two successive PLC cycles (***kShPImgSyncAlways***) or whether it is taken over on demand (***kShPImgSyncOnDemand***). If classified as *SyncOnDemand*, the data must be marked as modified by calling function *ShPImgClntWriteSectMarkNewData()*. It sets the member element *m_fNewData* to TRUE. The client application should never directly modify this member element.

Function *ShPImgClntSetup*

```
BOOL  ShPImgClntSetup  (tShPImgLayoutDscrpt* pShPImgLayoutDscrpt_p);
```

Function ***ShPImgClntSetup()*** initializes the *shared process image client* and connects itself with the storage segment for the shared process image which is generated by the PLC runtime system. Afterwards, it enters the start offsets and values of the input, ouput and merker sections into the structure of type *tShPImgLayoutDscrpt* provided upon function call. Hence, the client

application receives notice about the process image setup managed by the PLC firmware.

If the PLC runtime system is not active when the function is called or if it has not generated a shared process image (option *"Shared Process Image"* in the PLC configuration deaktivated, see section 7.1.1), the function will return with the return value FALSE. If the initialization was successful, the return value will be TRUE.

Function *ShPImgCIntRelease*

```
BOOL  ShPImgClntRelease  (void);
```

Function ***ShPImgCIntRelease()*** shuts down the s*hared process image client* and disconnects the the connection to the storage segment generated for the shared process image by the PLC runtime system.

If executed successfully, the function delivers return value TRUE. If an error occurrs, it will deliver return value FALSE.

Function *ShPImgCIntSetNewDataSigHandler*

```
BOOL  ShPImgClntSetNewDataSigHandler  (
         tShPImgAppNewDataSigHandler pfnShPImgAppNewDataSigHandler_p);
```

Funkcion ***ShPImgCIntSetNewDataSigHandler()*** registers a user-specific callback handler. This callback handler is called after a synchronization of both images. Registered callback handlers are cleared by the parameter NULL.

The **callback handler is called within the context of a Linux signal handler**. Accordingly, all common **restrictions** for the Linux signal handler also apply to the callback handler (see section 7.1.1).

If executed successfully, the function delivers return value TRUE. If an error occurrs, it will deliver return value FALSE.

Function *ShPImgCIntGetHeader*

```
tShPImgHeader*  ShPImgClntGetHeader  (void);
```

Function ***ShPImgCIntGetHeader()*** provides a pointer to the internally used structure type *tShPImgHeader* to manage the shared process image. The client application does usually not need this structure, because all data that it includes can be read and written through functions of the API provided by the *shared process image client*.

Function *ShPImgCIntGetDataSect*

```
BYTE*  ShPImgClntGetDataSect  (void);
```

Function ***ShPImgCIntGetDataSect()*** provides a pointer to the beginning of the shared process image. This pointer represents the basic address for all accesses to the shared process image; including the definition of sections *ReadSectorTable* and *WriteSectorTable* (see section 7.1.1).

Functions *ShPImgClntLockSegment* and *ShPImgClntUnlockSegment*

```
BOOL  ShPImgClntLockSegment  (void);
BOOL  ShPImgClntUnlockSegment  (void);
```

To exclusively access the shared process image, the client application has available two functions - function ***ShPImgClntLockSegment()*** to enter the critical section and function ***ShPImgClntUnlockSegment()*** to leave it. The segment between both functions is called protected section, because in this segment the client application holds unrivaled access to the shared process image (see section 7.1.1). The consistency of read or written data is only guaranteed within such a protected section. Outside the protected section, the shared process image may anytime be manipulated by the PLC runtime system. To ensure that the client application does not interfere with the PLC runtime system too much, the critical sections should be set as less as possible and only as long as necessary. Otherwise, the PLC cycle time may be extended and runtime variations (Jitter) may occur.

If executed successfully, the function delivers return value TRUE. If an error occurrs, it will deliver return value FALSE.

Function *ShPImgClntSetupReadSectTable*

```
BOOL  ShPImgClntSetupReadSectTable  (
         tShPImgSectDscrpt* paShPImgReadSectTab_p,
         unsigned int uiNumOfReadDscrptUsed_p);
```

Function ***ShPImgClntSetupReadSectTable()*** initializes the *ReadSectorTable* with the values defined by the client. The client hereby determines those sections of the PLC process image from which it wants to read data (see section 7.1.1). Parameter *paShPImgReadSectTab_p* holds elements of the structure *tShPImgSectDscrpt* and must be transferred as start address of a section. Parameter *uiNumOfReadDscrptUsed_p* indicates how many elements the section has.

kShPImgSyncAlways is provided as *SyncType* for the *ReadSectorTable*.

The maximum amount of possible elements for the *ReadSectorTable* is defined by the constant *SHPIMG_READ_SECT_TAB_ENTRIES* and can only be modified if the shared library "pc5484drv.so" is generated again and at the time (this requires SO-1098 - "Driver Development Kit for the PLCcore-5484", see section 7.2).

If executed successfully, the function delivers return value TRUE. If an error occurrs, it will deliver return value FALSE.

Function *ShPImgClntSetupWriteSectTable*

```
BOOL  ShPImgClntSetupWriteSectTable  (
         tShPImgSectDscrpt* paShPImgWriteSectTab_p,
         unsigned int uiNumOfWriteDscrptUsed_p);
```

Function ***ShPImgClntSetupWriteSectTable***() initializes the *WriteSectorTable* with the values defined by the client. The client hereby determines those sections of the PLC process image from which it wants to write data (see section 7.1.1). Parameter *paShPImgWriteSectTab_p* holds elements of structure *tShPImgSectDscrpt* and must be transferred as start address of a section. Parameter *uiNumOfWriteDscrptUsed_p* indicates how many elements the section has.

For each entry in the *WriteSectorTable* the *SyncType* must be defined. This *SyncType* defines whether the section is always taken over into the local image between two PLC cycles (***kShPImgSyncAlways***) or only on demand (***kShPImgSyncOnDemand***). If taken over on demand, the respective section is explicitly marked as updated by calling

ShPImgClntWriteSectMarkNewData().

The maximum amount of possible elements for the *WriteSectorTable* is defined by the constant *SHPIMG_WRITE_SECT_TAB_ENTRIES* and can only be modified if the shared library "pc5484drv.so" is generated again and at the same time (this requires SO-1098 - "Driver Development Kit für das PLCcore-5484", see section 7.2).

If executed successfully, the function delivers return value TRUE. If an error occurrs, it will deliver return value FALSE.

Function *ShPImgClntWriteSectMarkNewData*

```
BOOL  ShPImgClntWriteSectMarkNewData  (unsigned int uiWriteDscrptIdx_p);
```

For the content of a section that is held by the *WriteSectorTable*, function ***ShPImgClntWriteSectMarkNewData()*** marks this content as modified. This function is used (for sections with *SyncType* ***kShPImgSyncOnDemand***) to initiate the copy process of data from the shared process image into the local image of the PLC.

Function *ShPImgClntWriteSectMarkNewData()* directly accesses the header of the shared process image without setting a semaphore before. Hence, it may only be used within the protected section – in the code section between *ShPImgClntLockSegment()* and *ShPImgClntUnlockSegment()*.

If executed successfully, the function delivers return value TRUE. If an error occurrs, it will deliver return value FALSE.

7.1.3 Creating a user-specific client application

Software package SO-1095 ("VMware image of the Linux development system") is the precondition for the implementation of user-specific C/C++ applications. It contains a complete Linux development system in the form of a VMware image. Hence, it allows for an easy introduction into the C/C++ software development for the PLCcore-5484. Thus, the VMware image is the ideal basis to develop Linux-based user programs on the same host PC that already has the *OpenPCS* IEC 61131 programming system installed on it. The Vmware image of the Linux development system includes the GNU-Crosscompiler Toolchain for Freescale MCF54xx processors. Additionally, it includes essential server services that are preconfigured and usable for effective software development. Details about the VMware image of the Linux development system and instructions for its usage are described in the *"System Manual ECUcore-5484"* (Manual no: L-1102).

As illustrated in Figure 27, the user-specific C/C++ application uses the API (files *shpimgclient.c* and *shpimgclient.h*) which is provided by the *shared process image client*. The *shared process image client* is based on services provided by the *shared mmory cient* (fles *shmclient.c* and *shmclient.c*). Both client implementations are necessary to generate a user-specific C/C++ application. The archive of the s*hared process image demos* (***shpimgdemo.tar.gz***) contains the respective files. To create own user-specific client applications, it is recommended to use this demo project as the basis for own adaptions and extensions. Moreover, this demo project contains a make file with all relevant configuration adjustments that are necessary to create a Linux application for the PLCcore-5484. Table 19 lists all files of the archive *"shpimgdemo.tar.gz"* and classifies those as general part of the C/C++ application or as specific component for the demo project *"shpimgdemo"*.

Table 19: Content of the archive files "shpimgdemo.tar.gz"

File	Necessary for all C/C++ applications	In particular for demo *"shpimgdemo"*
shpimgclient.c	x	
shpimgclient.h	x	
shmclient.c	x	
shmclient.h	x	
shpimg.h	x	
global.h	x	
Makefile	draft, to be adjusted	
shpimgdemo.c		x
trmio.c		x
trmio.h		x
trace.c		x

The archive file ***"shpimgdemo.tar.gz"*** including the *shared process image demo* must be unzipped into any subdirectory following the path *"/projects/ECUcore-5484/user"* within the Linux development system. Therefore, command *"tar"* must be called:

```
tar xzvf shpimgdemo.tar.gz
```

During the upzipping process, command *"tar"* independently generates the subdirectory *"shpimgdemo"*. For example, if the command is called in directory *"/projects/ECUcore-5484/user"*, all archive files will be upzipped into the path *"/projects/ECUcore-5484/user/**shpimgdemo**"*. Figure 28 exemplifies the unzipping process of *"shpimgdemo.tar.gz"* within the Linux development system.

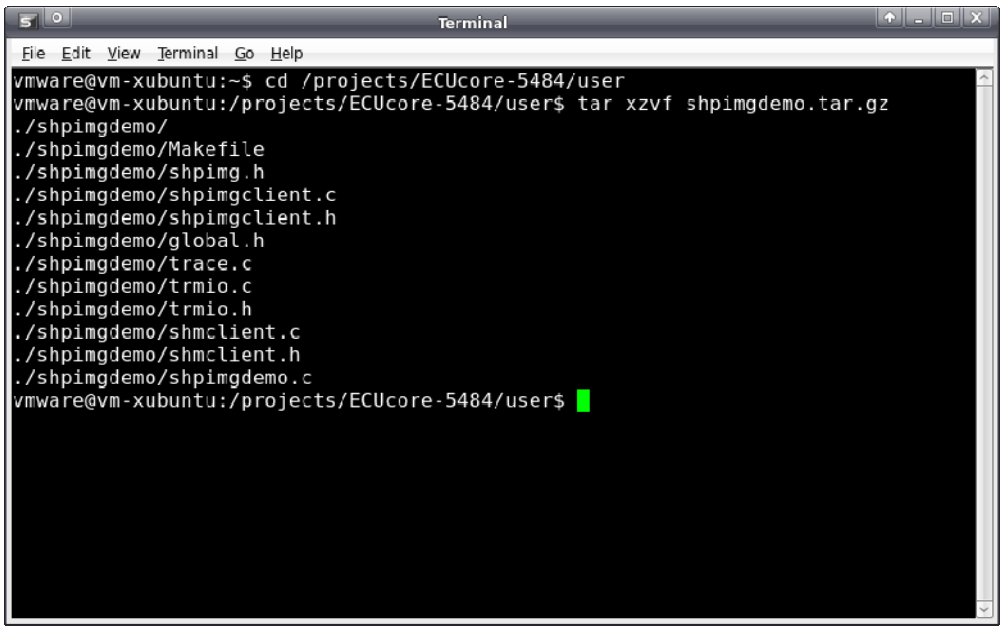


Figure 28: Upzipping the archive files shpimgdemo.tar.gz in the Linux development system

After upzipping and switchung into subdirectory *"shpimgdemo"*, the demo project can be created by calling command *"make"*:

```
cd  shpimgdemo
make
```

Figure 29 shows how the demo project *"shpimgdemo"* is generated in the Linux development system.

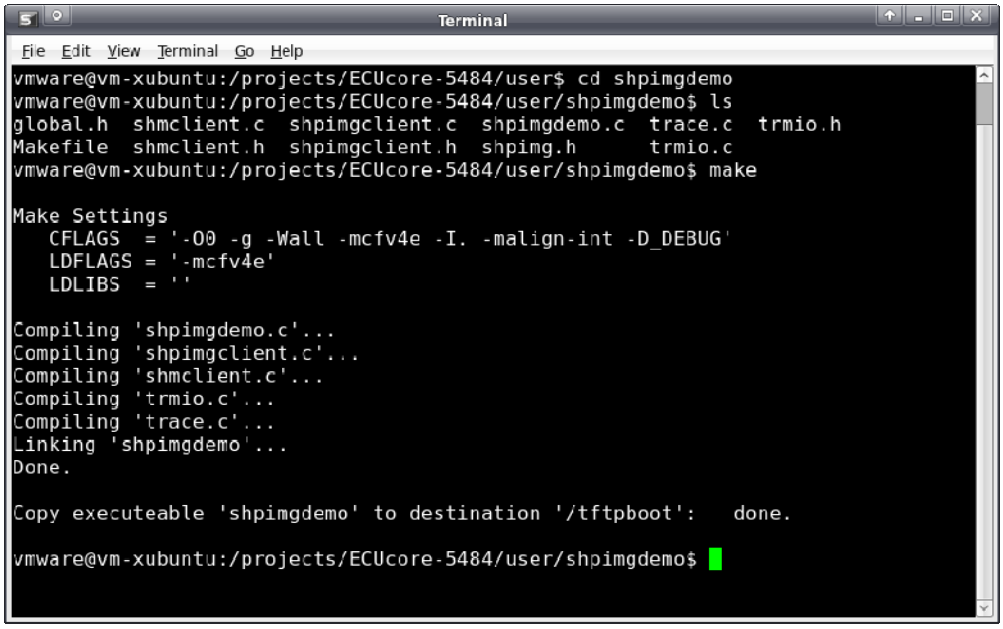


Figure 29: Generating the demo project "shpimgdemo" in the Linux development system

Section 7.1.4. describes the usage and handling of the demo project *"shpimgdemo"* on the PLCcore-5484.

7.1.4 Example for using the shared process image

The demo project *"shpimgdemo"* (described in section 7.1.3) in connection with the PLC program example *"RunLight"* both exemplify the data exchange between a PLC program and a user-specific C/C++ application.

Technical background

The PLC program generates some variables in the process image as directly addressable variables. In a C/C++ application, all those variables are usable via the shared process image. For the PLC program example *"RunLight"* those are the following variables:

```
(* variables for local control via on-board I/O's *)
bButtonGroup        AT %IB0.0   : BYTE;
iAnalogValue        AT %IW8.0   : INT;
bLEDGroup0          AT %QB0.0   : BYTE;
bLEDGroup1          AT %QB1.0   : BYTE;

(* variables for remote control via shared process image  *)
uiRemoteSlidbarLen  AT %MW512.0 : UINT;     (* out: length of slidebar         *)
bRemoteStatus       AT %MB514.0 : BYTE;     (* out: Bit0: RemoteControl=on/off *)
bRemoteDirCtrl      AT %MB515.0 : BYTE;     (* in:  direction left/right       *)
iRemoteSpeedCtrl    AT %MW516.0 : INT;      (* in:  speed                      *)
```

Variables of the PLC program are accessible from a C/C++ application via the shared process image. Therefore, sections must be generated for the *ReadSectorTable* and *WriteSectorTable* on the one hand and on the other hand, pointers must be defined for accessing the variables. The following program extract shows this using the example *"shpimgdemo.c"*. Function *ShPImgClntSetup()* inserts the start offsets of input, output and merker sections into the structure *ShPImgLayoutDscrpt*. Hence, on the basis of the initial address provided by *ShPImgClntGetDataSect()*, the absolute initial addresses of each section in the shared process image can be determined. To identify the address of a variable, the variable's offset within the particular section must be added. For example, the absolute address to access the variable *"bRemoteDirCtrl AT %MB515.0 : BYTE;"* results from the sum of the initial address of the shared process image (pabShPImgDataSect), the start offset of the merker section (*ShPImgLayoutDscrpt.m_uiPImgMarkerOffs für "%M..."*) as well as the direct address within the merker section which was defined in the PLC program (515 für "%MB515.0"):

```
    pbPImgVar_61131_bDirCtrl = (BYTE*) (pabShPImgDataSect
               + ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 515);
```

The following code extract shows the complete definition of all variables in the demo project used for exchanging data with the PLC program:

```
// ---- Setup shared process image client ----
fRes = ShPImgClntSetup (&ShPImgLayoutDscrpt);
if ( !fRes )
{
    printf ("\n*** ERROR *** Init of shared process image client failed");
}

pabShPImgDataSect = ShPImgClntGetDataSect();


// ---- Read Sector Table ----
// Input Section:       bButtonGroup AT %IB0.0
{
    ShPImgReadSectTab[0].m_uiPImgDataSectOffs =
                ShPImgLayoutDscrpt.m_uiPImgInputOffs + 0;
    ShPImgReadSectTab[0].m_uiPImgDataSectSize = sizeof(BYTE);
    ShPImgReadSectTab[0].m_SyncType           = kShPImgSyncAlways;

    pbPImgVar_61131_bButtonGroup = (BYTE*) (pabShPImgDataSect
               + ShPImgLayoutDscrpt.m_uiPImgInputOffs + 0);
}

// Output Section:      bLEDGroup0 AT %QB0.0
//                      bLEDGroup1 AT %QB1.0
{
    ShPImgReadSectTab[1].m_uiPImgDataSectOffs =
                ShPImgLayoutDscrpt.m_uiPImgOutputOffs + 0;
    ShPImgReadSectTab[1].m_uiPImgDataSectSize = sizeof(BYTE) + sizeof(BYTE);
    ShPImgReadSectTab[1].m_SyncType           = kShPImgSyncAlways;

    pbPImgVar_61131_bLEDGroup0 = (BYTE*) (pabShPImgDataSect
               + ShPImgLayoutDscrpt.m_uiPImgOutputOffs + 0);
    pbPImgVar_61131_bLEDGroup1 = (BYTE*) (pabShPImgDataSect
               + ShPImgLayoutDscrpt.m_uiPImgOutputOffs + 1);
}
```

```
// Marker Section:      uiSlidbarLen AT %MW512.0
//                      bStatus      AT %MB514.0
{
    ShPImgReadSectTab[2].m_uiPImgDataSectOffs =
                ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 512;
    ShPImgReadSectTab[2].m_uiPImgDataSectSize =   sizeof(unsigned short int)
                                                + sizeof(BYTE);
    ShPImgReadSectTab[2].m_SyncType           = kShPImgSyncAlways;

    pbPImgVar_61131_usiSlidbarLen = (unsigned short int*) (pabShPImgDataSect
              + ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 512);
    pbPImgVar_61131_bStatus = (BYTE*) (pabShPImgDataSect
              + ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 514);
}

fRes = ShPImgClntSetupReadSectTable (ShPImgReadSectTab, 3);
if ( !fRes )
{
    printf ("\n*** ERROR *** Initialization of read sector table failed");
}

// ---- Write Sector Table ----
// Marker Section:      bDirCtrl   AT %MB513.0
//                      iSpeedCtrl AT %MB514.0
{
    ShPImgWriteSectTab[0].m_uiPImgDataSectOffs =
                ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 515;
    ShPImgWriteSectTab[0].m_uiPImgDataSectSize = sizeof(BYTE) + sizeof(WORD);
    ShPImgWriteSectTab[0].m_SyncType           = kShPImgSyncOnDemand;

    pbPImgVar_61131_bDirCtrl = (BYTE*) (pabShPImgDataSect
              + ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 515);
    psiPImgVar_61131_iSpeedCtrl = (short int*) (pabShPImgDataSect
                  + ShPImgLayoutDscrpt.m_uiPImgMarkerOffs + 516);
}

fRes = ShPImgClntSetupWriteSectTable (ShPImgWriteSectTab, 1);
if ( !fRes )
{
    printf ("\n*** ERROR *** Initialization of write sector table failed");
}
```

Realization on the PLCcore-5484

To enable the execution of the *shared process image demo* without previous introduction into the Linux-based C/C++ programming for the PLCcore-5484, the modul comes with a preinstalled, translated and ready-to-run program version and PLC firmware (*"/home/plc/shpimgdemo"*). The following description refers to this program version. Alternatively, the demo project can be newly-generated from the corresponding source files (see section 7.1.3) and can be started afterwards.

The following steps are necessary to run the *shared process image demo* on the PLCcore-5484:

1. **Activate option *"Shared Process Image"*** in the PLC configuration (see section 7.1.1, 5.3.1 and 5.3.3).

2. Open the PLC program example *"RunLight"* in the *OpenPCS* IEC 61131 programming system und translate the project for the target hardware of the type *"SYSTEC - PLCcore-5484"*.

3. Select the network connection to the PLCcore-5484 und download the program.

4. Start the PLC program on the PLCcore-5484.

5. Login to the command shell of the PLCcore-5484 as described in section 6.3.1.

6. Switch to the directory *"/home/plc"* and call the demo proogram *"shpimgdemo"*:

```
cd  /home/plc
./shpimgdemo
```

The digital outputs of the PLCcore-5484 are selected as runlight. The speed is modifiable via the analog input AI0 (Poti at the ADC of the development board). With the help of pushbuttons S0 and S1, the running direction can be changed. After starting the demo program *"shpimgdemo"* on the PLCcore-5484, actual status information about the runlight is indicated cyclically in the terminal (see Figure 30).

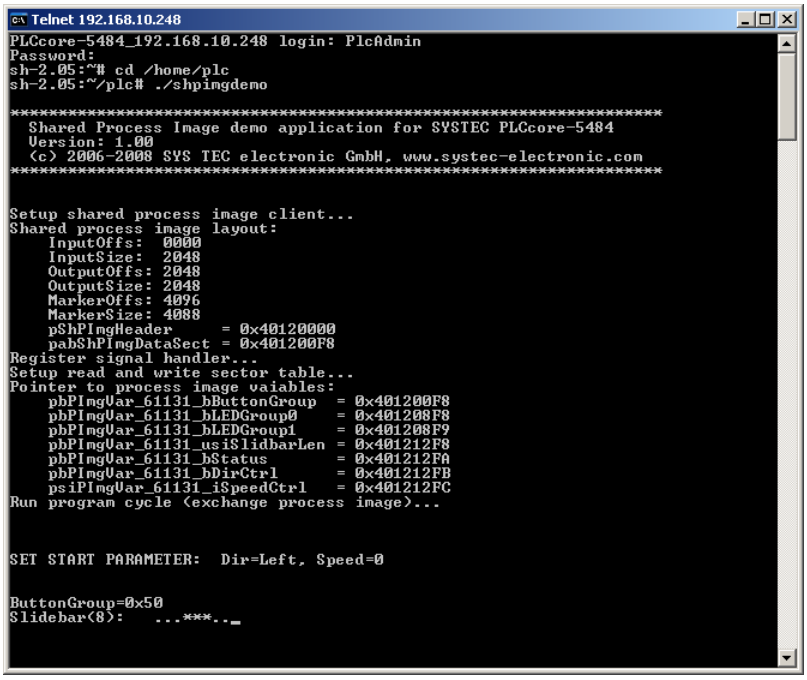


Figure 30: Terminal outputs of the demo program "shpimgdemo" after start

7. By pressing pushbutton S3, the control of the runlight direction and speed is handed over to the demo program *"shpimgdemo"*. Afterwards, the running direction may be set by the C application by using the cursor pushbuttons left and right (← und →) in the terminal window and the speed may be changed by using cursor pushbuttons up and down (↑ und ↓).

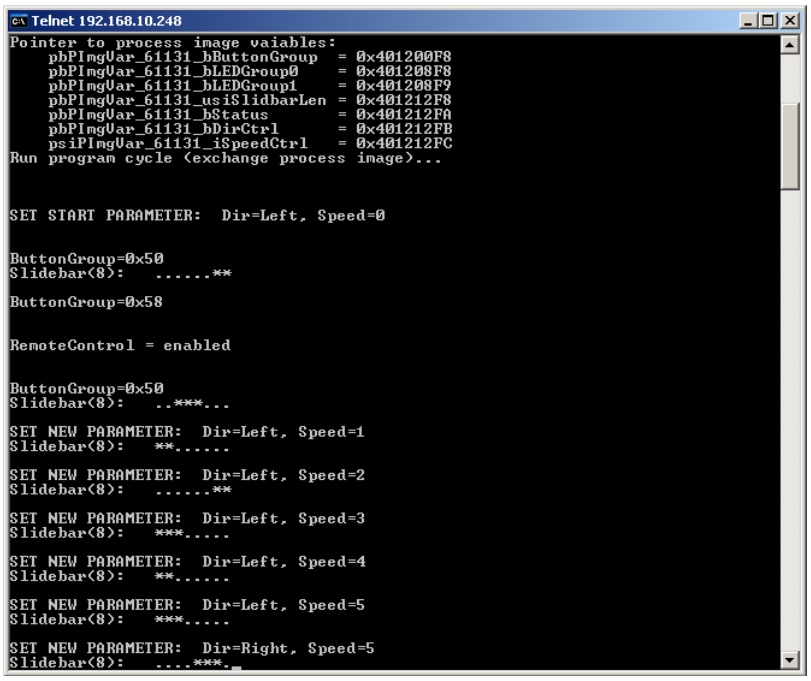


Figure 31: Terminal ouputs of the demo program "shpimgdemo" after user inputs

Figure 31 shows the terminal outputs of the demo program *"shpimgdemo"* in answer to activating the cursor pushbuttons.

The demo program *"shpimgdemo"* may be terminated by pressing "Ctrl+C" in the terminal window.

7.2 Driver Development Kit (DDK) for the PLCcore-5484

The Driver Development Kit (DDK) for the PLCcore-5484 is distributed as additional software package with the order number SO-1098. It is not included in the delivery of the PLCcore-5484 or the Development Kit PLCcore-5484. The "Software Manual Driver Development Kit for the ECUcore-5484" (Manual no.: L-1220) provides details about the DDK.

The Driver Development Kit for the PLCcore-5484 enables the user to adapt an I/O level to self-developed baseboards. The Embedded Linux on the PLCcore-5484 supports dynamic loading of drivers during runtime. Hence, it allows for a separation of the PLC runtime system and I/O drivers. Consequently, the user is able to completely adapt the I/O driver to own requirements – without having to modify the PLC runtime system.

By using the DDK, the following ressources may be integrated into the I/O level:

- Periphery (usually GPIO) of the MCF5484
- On-board PLD (Lattice MACH XO 640)
- FlexBus (memory-mapped via address-/databus)
- SPI-Bus and I^2C-Bus
- All other ressources provided by the operating system, e.g. file system and TCP/IP

Figure 32 provides an overview of the DDK structure and its components. The DDK contains PLD software sources (VHDL), the Linux kernel driver (pc5484drv.ko) and the Linux user library (pc5484drv.so). Additionally, the DDK includes a PLD Programming Tool (pldtool + plddrv.ko) which allows for a PLD software update without extra JTAG hardware.

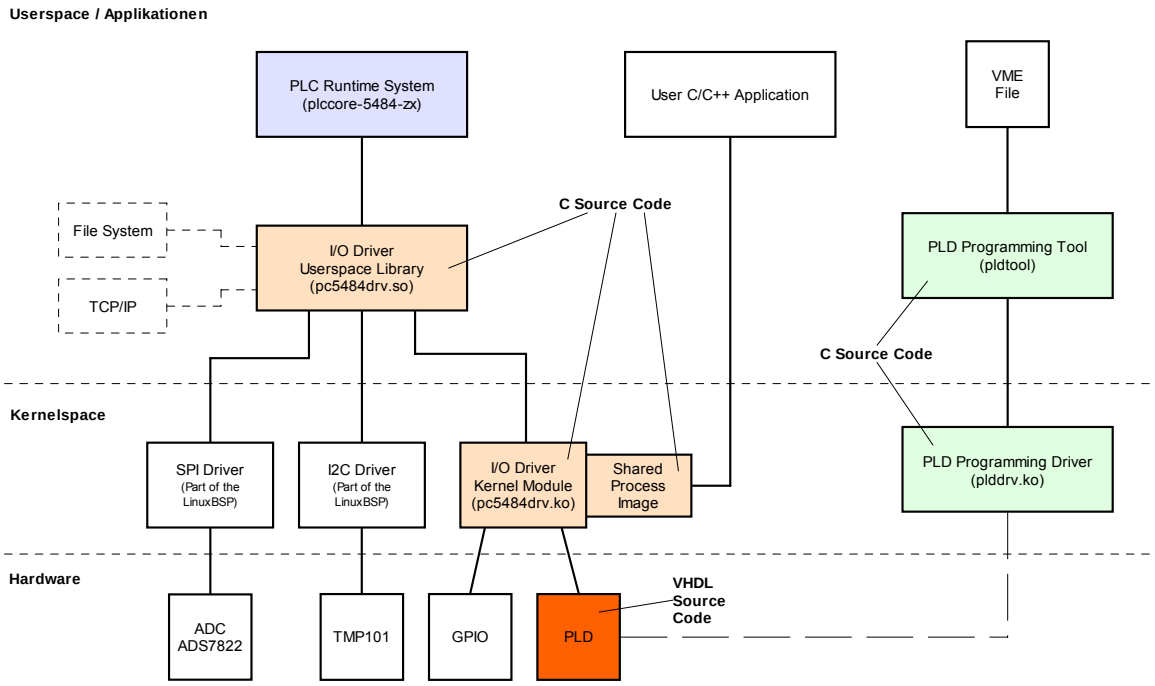


Figure 32: Overview of the Driver Development Kit for the PLCcore-5484

Scope of delivery / components of the DDK:

The DDK contains the following components:

1. VHDL project for the PLD; comprises all files necessary to regenerate PLD software (VHLS source files, pin assignment, timing settings, project file etc.)

2. Source code for the Linux kernel driver (pc5484drv.ko, see Figure 32); includes all files necessary to regenerate kernel drivers (C and H files, Make file etc.)

3. Source code for the Linux user library (pc5484drv.so, see Figure 32); contains all files necessary to regenerate a user library (C and H files, Make file etc.)

4. PLD Programming Tool (pldtool + plddrv.ko); enables a PLD software update using Linux without additional JTAG hardware

5. I/O driver demo application (iodrvdemo) in the source code; allows for a quick and trouble-free test of the I/O drivers

6. Documentation

The Driver Development Kit is based on the software package **SO-1095** ("VMware-Image of the Linux development system"). It contains sources of the LinuxBSP used and it includes the necessary GNU-Crosscompiler Toolchain for Freescale MCF54xx processors.

7.3 Testing the hardware connections

The PLCcore-5484 primarily is designed as vendor part for the application in industrial controls. Hence, the PLCcore-5484 typically is integrated in a user-specific baseboard. To enable trouble-free inspection of correct I/O activation, the test program *"iodrvdemo"* is installed on the module together

with the PLC firmware. This test program is directly tied in with the I/O driver and allows quick and direct access to the periphery.

At first, if a PLC runtime system is running, it must be quit. This is to ensure that the test program *"iodrvdemo"* receives exclusive access to all I/O resources. To do so, script *"stopplc"* may possibly be called:

```
cd  /home/plc
./stopplc
```

Afterwards, the I/O driver may be reloaded and the test program *"iodrvdemo"* may be started:

```
insmod  pc5484drv.ko
./iodrvdemo
```

Figure 33 exemplifies the testing of the hardware connections using *"iodrvdemo"*.

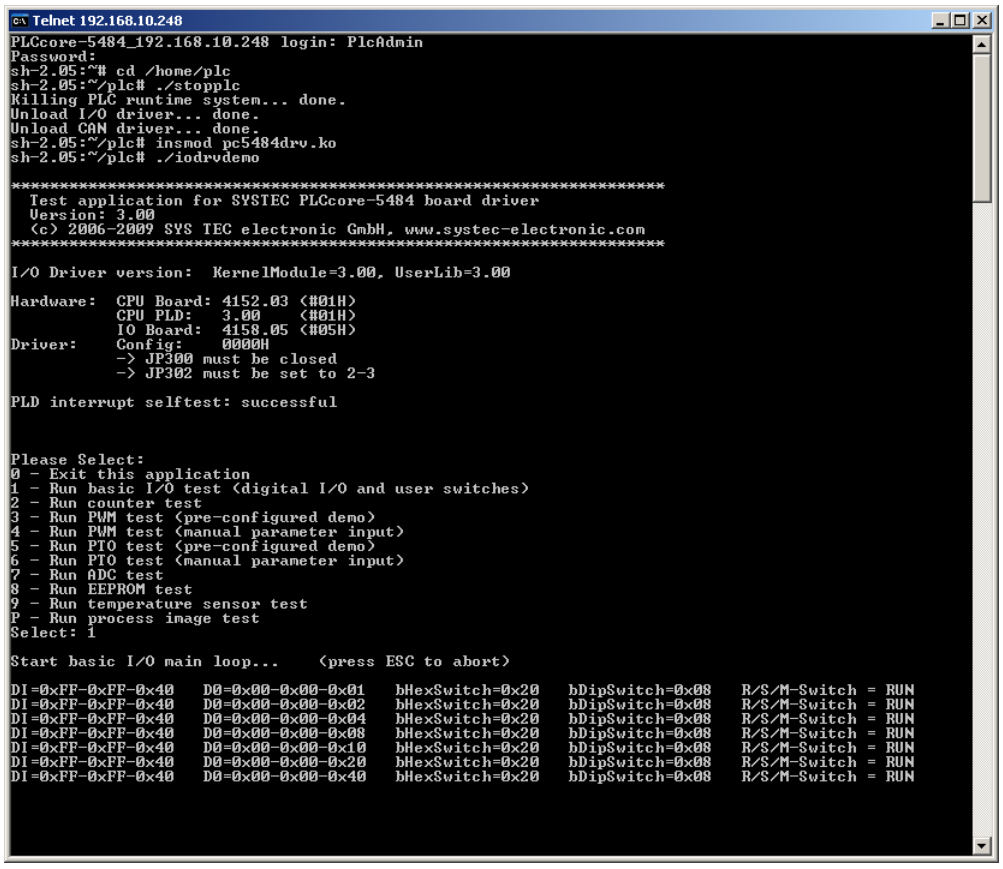

Telnet 192.168.10.248
PLCcore-5484_192.168.10.248 login: PlcAdmin
Password:
sh-2.05:~# cd /home/plc
sh-2.05:~/plc# ./stopplc
Killing PLC runtime system... done.
Unload I/O driver... done.
Unload CAN driver... done.
sh-2.05:~/plc# insmod pc5484drv.ko
sh-2.05:~/plc# ./iodrvdemo
Test application for SYSTEC PLCcore-5484 board driver
Version: 3.00
(c) 2006-2009 SYS TEC electronic GmbH, www.systec-electronic.com
I/O Driver version: KernelModule=3.00, UserLib=3.00
Hardware: CPU Board: 4152.03 (#01H)
CPU PLD: 3.00 (#01H)
IO Board: 4158.05 (#05H)
Driver: Config: 0000H
-> JP300 must be closed
-> JP302 must be set to 2-3
PLD interrupt selftest: successful
Please Select:
0 - Exit this application
1 - Run basic I/O test (digital I/O and user switches)
2 - Run counter test
3 - Run PWM test (pre-configured demo)
4 - Run PWM test (manual parameter input)
5 - Run PTO test (pre-configured demo)
6 - Run PTO test (manual parameter input)
7 - Run ADC test
8 - Run EEPROM test
9 - Run temperature sensor test
P - Run process image test
Select: 1
Start basic I/O main loop... (press ESC to abort)
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x01 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x02 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x04 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x08 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x10 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x20 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN
DI=0xFF-0xFF-0x40 D0=0x00-0x00-0x40 bHexSwitch=0x20 bDipSwitch=0x08 R/S/M-Switch = RUN

Figure 33: Testing the hardware connections using "iodrvdemo"

Appendix A: Reference design for the PLCcore-5484

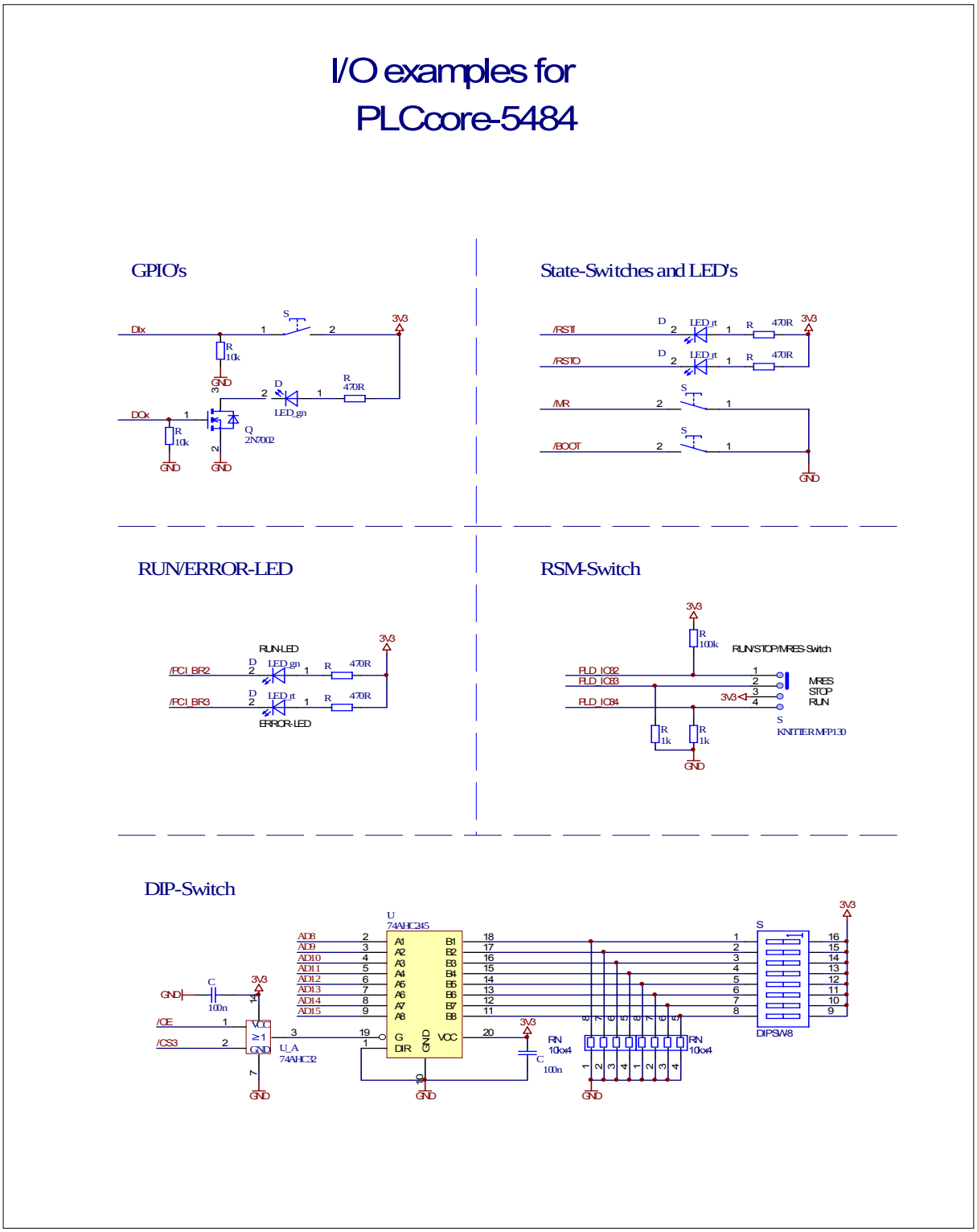


Figure 34: Reference design for I/O interface connection

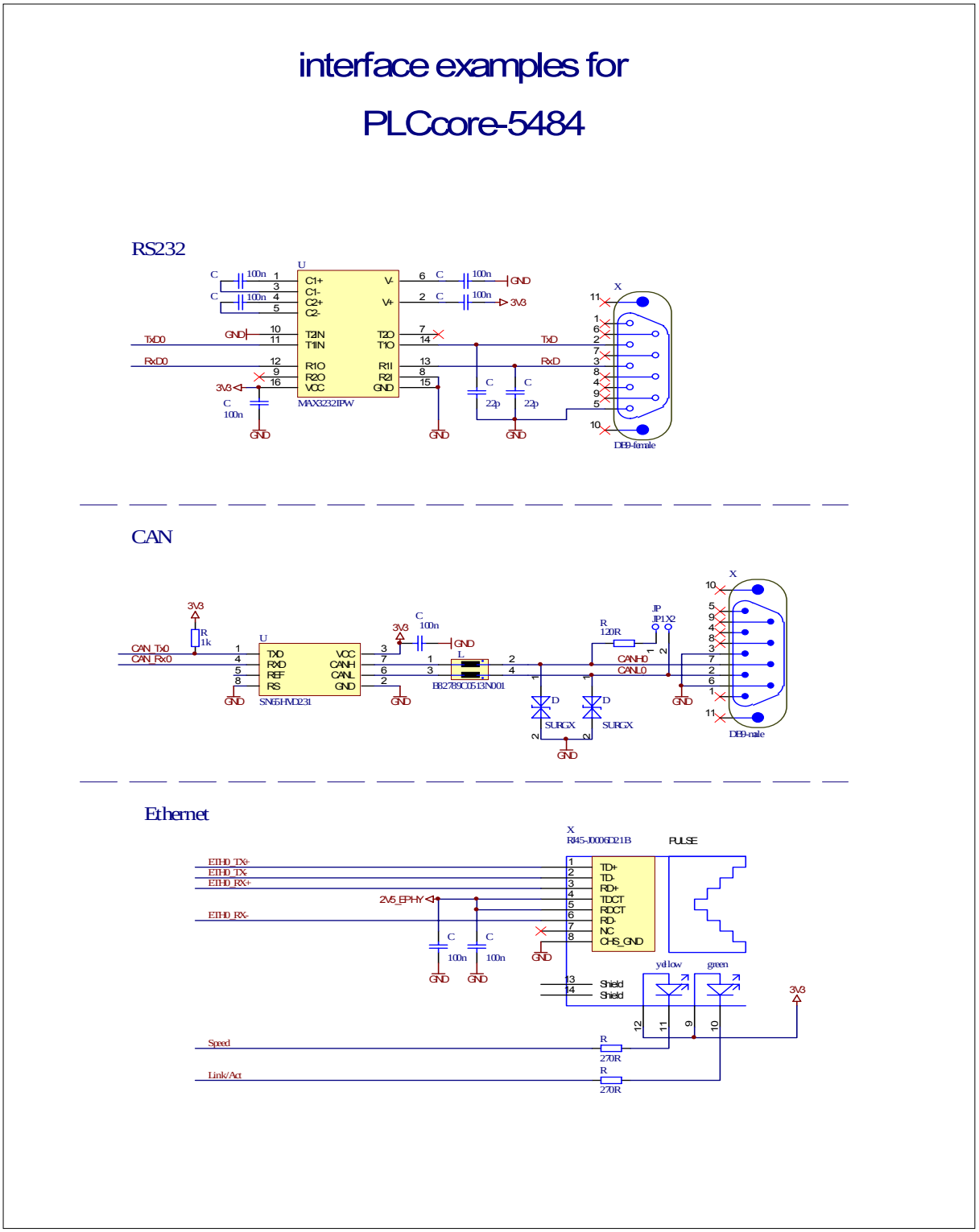


Figure 35: Reference design for interface circuit

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Version 2, June 1991

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